The 1990 National Shellfish Register of Classified Estuarine Waters

U. S. Department of Commerce
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Cover Photo:
Cultured Blue Mussels, Rhode Island
by Joseph H. Bailey

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Introduction

The 1990 National Shellfish Register of Classified Estuarine Waters (Register) describes declines in estuarine water quality, decreases in the acreage of approved molluscan shellfish-growing waters, and continuing declines in the Nation's shellfish harvests. Relationships between these declines are discussed. Although declines in any given year, and even from 1985 to 1990, are not dramatic, an almost inexorable trend that threatens to destroy the harvest of wild or natural shellfish continues throughout the Nation's coastal areas.

The Register has recorded changes in the classification of molluscan shellfish-growing waters since 1966, when there were nine million acres of estuarine waters classified (Table 2). Produced every five years, the Register has evolved from a tabular report on classifications to a detailed analysis supported by an electronic data base and mapping system developed by the National Oceanic and Atmospheric Administration (NOAA).

The 1990 Register covers 3,172 shellfishing areas encompassing 18.7 million acres of classified estuarine and offshore waters in 23 states. The data are aggregated by 122 estuaries and sub-estuaries, most of which are identified in NOAA's National Estuarine Inventory (NEI) (Appendix A). The current NEI does not contain data for Alaska and Hawaii. For Alaska, the data in the Register are organized by five fisheries management districts. Non-estuarine shellfishing areas extending seaward to the three-mile limit (offshore areas), account for about 1.5 million acres and are treated separately.

Register Process. The 1990 Register is the culmination of five years of data collection and analysis. Following the 1985 Register, shellfish-growing waters were aggregated by estuary according to NOAA's NEI (NOAA, 1985). The classifications of shellfishing areas could then be considered in conjunction with human activities and natural conditions across entire watersheds. This expansion of the Register data base resulted in a series of regional reports produced between 1988 and 1990 that clarified: (1) classifications of shellfishing areas; (2) water quality trends; (3) pollution sources affecting classifications; (4) State program resources; and (5) trends in landings.

The 1990 Register process began in February 1990, when NOAA initiated investigations with State shellfish management agencies (Alaska and Hawaii were added to the survey and Pennsylvania was deleted). Data were collected on classified areas and compiled on 280 NOAA nautical charts. Data also were collected on pollution sources, shoreline surveys of actual and potential pollution sources, water quality sampling results, commercial shellfish landings, program budgets, and personnel.

Table 1. *Classifications for Commercial Shellfish-Growing Waters* [a]

Approved (APP)	Waters may be harvested for direct marketing at all times.
Conditionally Approved (CON)	Waters do not meet the criteria for approved waters if subjected to intermittent microbiological pollution, but may be harvested when criteria are met.
Restricted (RES)	Waters may be harvested if shellfish are subjected to a suitable purification process.
Prohibited (PRO)	No harvest for human consumption at any time.

a. Harvest-limited refers to the sum of shellfish-growing waters that are classified Conditionally Approved, Prohibited, and Restricted.

The 1990 classified areas were compared with those for 1985. Changes in acreage were estimated and entered into the Register data base. Newly classified areas including all areas in Alaska and Hawaii were measured with an automated planimeter. All chart data used in the Register are being digitized to provide precise acreages and a digital map data base to replace the manually maintained charts. A supplement to the 1990 Register that presents data on each shellfishing area is in preparation and will be available from NOAA.

Classifying Waters to Protect Public Health. The National Shellfish Sanitation Program (NSSP) classifies shellfish-growing waters to protect public health. The NSSP is a cooperative program involving states, industry, and the Federal government. Since 1983, it has been administered through the Interstate Shellfish Sanitation Conference (ISSC). The ISSC was formed to promote shellfish sanitation, adopt uniform procedures, and develop comprehensive guidelines to regulate the harvesting, processing, and shipping of shellfish.

National Shellfish Sanitation Program

The NSSP assumes that a relationship exists between pollution from human activities, shellfish-growing waters, and human disease. Pathogens (disease-causing bacteria or viruses) may enter waters through direct discharges of untreated or poorly treated human wastes or through nonpoint runoff from streets, farms, or construction sites. Bivalve molluscs, such as oysters, filter large volumes of water, and concentrate pollutants and pathogens.

The NSSP requires each state to classify shellfish-growing waters using sanitary surveys that: (1) identify actual or potential pollution sources; (2) evaluate hydrology and meteorology affecting pollutant transport; and (3) sample waters for bacterial quality (at least five times annually for each station). Waters are

classified into four categories described in Table 1. Table 2 shows estuarine acres classified since 1966.

Public health concerns also focus on changing environmental conditions that affect pathogens, density and distribution of human pathogens, harvest practices, and the increasing risks of human disease (FDA, 1990).

Enteric Diseases. For nearly a century, shellfish have been recognized as vehicles of foodborne enteric disease. Although the implementation of the NSSP in 1925 led to the control of bacterial pathogens such as cholera and typhoid fever, the occurrence of shellfish-associated viral diseases (10,384 cases through 1989) has increased (G. Richards, Pers. Comm.). For example, since 1961 almost 1,400 cases of oyster- and clam-associated hepatitis A have been documented nationally.

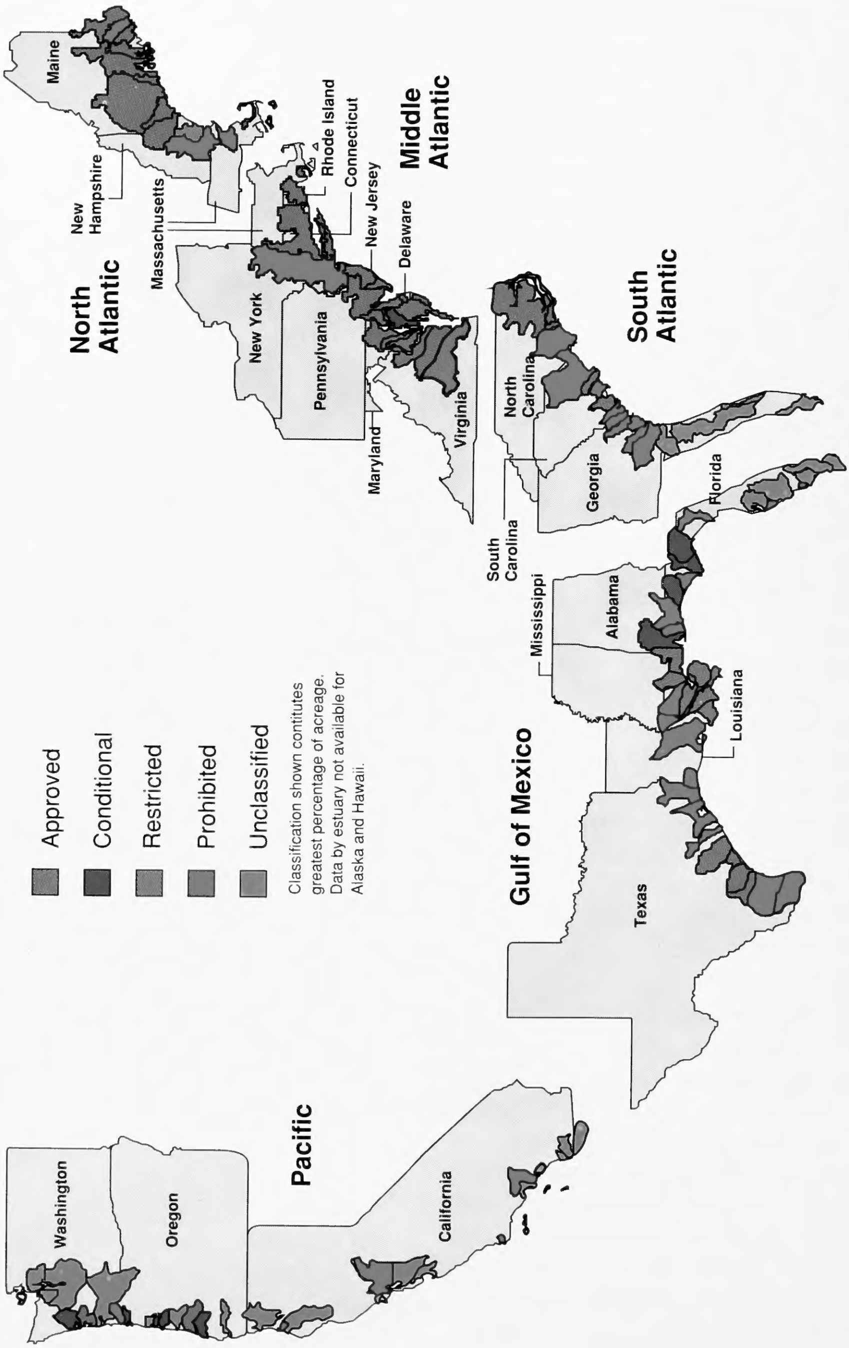
Vibrio Bacteria. Vibrios are a group of bacteria found naturally in saline coastal waters. Recent outbreaks (334 cases between 1973 and 1987) have been associated with *Vibrio cholerae, V. vulnificus*, and *V. parahaemolyticus.* Ingestion of *Vibrio* can cause gastroenteritis and even death, particularly in compromised patients. In 1988, 43 cases of *V. vulnificus* were reported, resulting in 18 deaths nationwide (Centers for Disease Control, 1989). However, only 27 cases and twelve deaths were linked to shellfish consumption (S. Rippey, Pers. Comm.). In Apalachicola Bay (FL), *V. cholerae* have been found in approved and prohibited waters; there was no correlation between coliform bacteria levels and *Vibrio* (Blake and Roderick, 1983). Deaths linked to out-of-state shipments suggest that handling and transport time may affect the pathogenicity of the organisms.

Marine Biotoxins. Shellfish-growing waters may be affected by blooms of certain species of dinoflagellates or diatoms. Blooms which produce marine biotoxins can cause a variety of human illnesses. On the North Atlantic Coast, paralytic shellfish poisoning (PSP) is caused by *Alexandrium tamarense*, which

Table 2. *Classified Estuarine Acres (x 1,000), 1966-1990*

State	1966	1971	1974	1980	1985	1990
Maine	352	1,045	1,045	1,045	1,034	902
New Hampshire	0	0	0	11	13	13
Massachusetts	39	344	344	304	312	406
Rhode Island	96	127	127	128	135	135
Connecticut	63	318	318	392	425	357
New York	551	632	632	1,021	1,096	1,077
New Jersey	520	395	395	395	392	403
Delaware	214	233	233	230	231	231
Maryland	1,198	1,454	1,318	1,424	1,375	1,375
Virginia	1,412	1,443	1,444	1,498	1,575	1,575
North Carolina	973	1,991	1,990	2,126	2,245	2,286
South Carolina	183	275	276	279	279	279
Georgia	141	204	204	204	168	168
Florida	1,250	1,768	1,767	930	961	1,206
Alabama	405	356	356	373	354	371
Mississippi	122	109	106	390	433	434
Louisiana	1,011	1,763	2,468	1,781	3,358	3,394
Texas	486	1,109	1,109	1,136	1,851	1,897
California	7	278	278	274	110	129
Oregon	5	29	28	39	39	36
Washington	44	224	223	244	243	262
Alaska	ND	ND	ND	ND	0	198
Hawaii	ND	ND	ND	ND	0	18
Total	**9,071**	**14,097**	**14,662**	**14,223**	**16,626**	**17,152**

Figure 1. *Predominant Classifications of Shellfish-Growing Waters*



produces the neurotoxin saxitoxin. Maine was the first state in the Nation to monitor for paralytic shellfish poisoning. As a result, some of the State's productive shellfish-growing waters have been closed for most years since 1958. In the Pacific region, the main toxic species causing PSP is *Protogonyalaux catenella.* Neurotoxic shellfish poisoning (NSP) may result from a bloom of the dinoflagellate *Ptychodiscus brevis.* Restricted to the west coast of Florida until the late 1980s, *P. brevis* recently caused blooms in Texas and North and South Carolina, and all four states have developed monitoring and assay programs at considerable cost. Amnesic shellfish poisoning (ASP), caused by acid released from the diatom *Nitzschia pungens* has recently been identified in mussels from Canadian waters. The disease, which has recently become a concern in the North Atlantic region, causes both gastrointestinal and neurological disorders, and is assayed using high performance liquid chromatography. Diarrhetic shellfish poisoning (DSP), caused by several species of *Dinophysis,* has been identified in Japan, Europe, and Canada. Because the symptoms of DSP are easily confused with those of other enteric diseases, U.S. cases may have gone unreported.

Through the use of NSSP marine biotoxin guidelines which require monitoring and tissue assay, coastal states have generally succeeded in eliminating toxic shellfish from commercial distribution. However, recreational harvesters are often unaware

Table 3. *Distribution of Classified Estuarine Waters, 1985 and 1990*

	Percent Classified							
	Approved		Prohibited		Conditional		Restricted	
Region	85	90	85	90	85	90	85	90
North Atlantic	87	69	10	29	1	1	2	1
Middle Atlantic	82	79	11	13	3	4	4	4
South Atlantic	75	71	22	21	3	4	<1	4
Gulf of Mexico	54	48	24	34	17	16	6	1
Pacific	42	53	40	31	18	11	1	5
Total	**69**	**63**	**19**	**25**	**9**	**9**	**4**	**3**

of biotoxin risks, and may ignore warnings if waters are not discolored. Accordingly, the majority of PSP cases in the United States result from the recreational harvest of clams and mussels (Nishitani, 1988).

National Overview

Information collected on the status of 3,172 individual shellfish-growing areas in the U.S. is presented for five

Table 4. *Classified Offshore Acres (x1,000), 1990*

State	Approved	Harvest-Limited
Maine	884	0
Massachusetts	349	45
New Jersey	206	59
California	<1	<1
Total	1,440	104

Table 5. *Pollution Sources Affecting Harvest-Limited Acreage, 1990* [a,b]

	North Atlantic		Middle Atlantic		South Atlantic		Gulf of Mexico		Pacific		Nationwide	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Point Sources												
Sewage Treat Plants	238	*67*	641	*57*	374	*44*	973	*27*	75	*25*	2,307	*37*
Combined Sewers	21	*6*	224	*20*	0	*0*	211	*6*	0	*0*	457	*7*
Direct Discharge	1	*<1*	84	*7*	5	*1*	920	*25*	6	*2*	1,015	*16*
Industry	21	*7*	223	*20*	180	*21*	522	*14*	129	*42*	1,077	*17*
Nonpoint Sources												
Septic Systems	91	*26*	123	*11*	288	*34*	1,763	*48*	57	*19*	2,322	*37*
Urban Runoff	75	*23*	655	*58*	290	*34*	1,276	*35*	110	*36*	2,412	*38*
Agricultural Runoff	5	*3*	130	*12*	233	*28*	301	*8*	41	*13*	718	*11*
Wildlife	19	*7*	112	*10*	306	*36*	1,115	*30*	39	*13*	1,597	*25*
Boats	55	*17*	353	*31*	146	*17*	507	*14*	47	*15*	1,113	*18*
Upstream Sources												
Sewage Treat Plants	2	*1*	104	*9*	9	*1*	1,174	*32*	45	*16*	1,334	*21*
Combined Sewers	0	*0*	5	*<1*	0	*0*	134	*4*	0	*0*	0	*2*
Urban Runoff	3	*1*	72	*6*	8	*1*	793	*22*	43	*14*	918	*15*
Agricultural Runoff	0	*0*	1	*<1*	0	*0*	435	*12*	0	*0*	436	*7*
Wildlife	0	*0*	28	*2*	35	*4*	210	*6*	0	*0*	273	*4*

a. Acres are times 1,000; % is percent of all harvest-limited acreage in region.
b. Since the same percentage of a shellfish area can be affected by more than one source, the percentages shown above cannot be added. They will not sum to 100.

coastal regions, 23 states, 122 estuaries, and in Alaska, five fisheries management areas (Figure 1). The total acreage of all estuarine growing areas is approximately 21.1 million acres; 81 percent of these (17.2 million acres) are classified for harvest. Information also is presented on an additional 1.5 million acres of classified offshore waters (from shore to the three-mile limit). Classifications for states and estuaries are provided in Appendices B and C.

Classified Acreage. Of the 17.2 million acres of estuarine waters that were classified for harvest as of January 1, 1990, 63 percent were approved for harvest and 37 percent were harvest-limited (Table 3). Of the harvest-limited acreage, about nine percent was conditionally approved.

Four states have begun to classify *offshore waters*, 93 percent of which are approved. Harvest-limited acreage (seven percent) in these areas is primarily a result of management

closures due to insufficient State resources for monitoring (Table 4).

Although many states do not classify offshore waters, in 1989, NOAA's National Marine Fisheries Service (NMFS) reported nationwide landings of over 118 million pounds of molluscan shellfish caught within zero to three miles offshore (NMFS, 1990). Given the pollution discharges such as sewage outfalls, into these waters, more offshore areas are likely to be classified as harvest-limited.

During the data collection process for the 1985 and 1990 Registers, the reasons an area was classified as harvest-limited were entered directly on the charts and later analyzed. State personnel were interviewed to determine whether classification changes between 1985 and 1989 were directly related to changes in water quality (less than two percent), or were a result of management decisions (over 98 percent). Water quality changes were supported by sanitary surveys that identify pollution sources, successful clean-up efforts, and sampling results.

Management decisions fall into three major categories: 1) those based on increased monitoring; 2) those based on political judgements; and 3) a default position, where areas are classified as prohibited because NSSP regulations requiring current and complete sanitary surveys have not been met. Because State officials have promoted increased monitoring activities, the amount of harvest-limited waters has increased nationally. Many states have developed conditional management plans for areas with predictable water quality fluctuations. Implementing such plans often requires additional resources at a time when many states are reducing their budgets. As the amount of harvestable area is reduced, industrial and political pressure may force states to re-open harvest areas which require close surveillance.

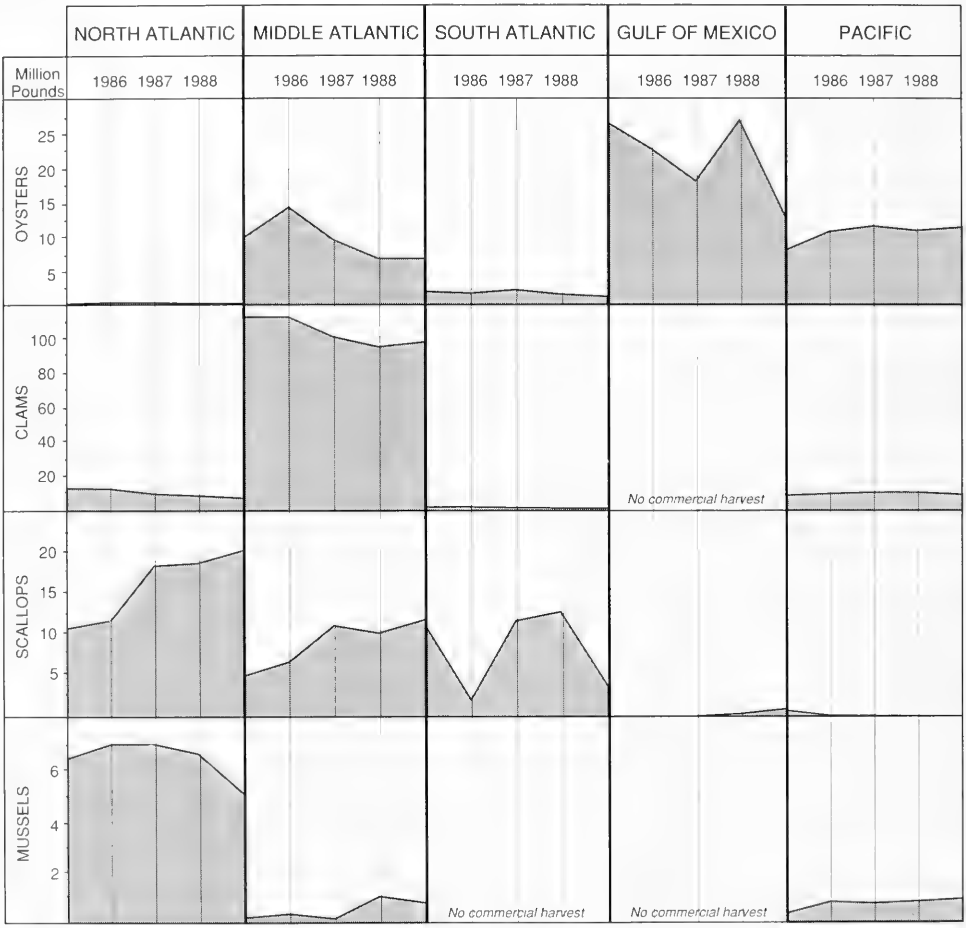
Effects of Pollution

The effect of a pollution source on shellfish-growing waters depends on the amount of coliform bacteria discharged, the dilution and dispersion factors, flushing ability related to tides and circulation, size of the growing area, and the presence of other pollution sources.

Although management capabilities vary greatly from state to state, about half are able to survey and sample most areas with harvest potential while the rest leave at least some productive waters closed because of inadequate management resources. Several states survey and sample an area only if there are active leases or after a lease application is received.

Pollution Sources Affecting Harvest. Pollution sources affecting an area were identified primarily through sanitary surveys conducted by State agencies. Only sources that significantly affect the classification of shellfish-growing areas were identified. A pollution source may be identified in a sanitary survey despite

Figure 2. *Commercial Shellfish Landings for Selected Species, 1985-1989*



a small contribution of coliform bacteria. In the case of some sources, additional shellfishing areas may be classified as buffer or safety zones, anticipating plant closures or bypasses, and in response to seasonal increases in boating activity. Table 5 shows the acres and percent of harvest-limited acreage in each region adversely affected by 14 pollution source categories. The acreage and percent of harvest-limited acreage in each estuary affected by each pollution source category is shown in Appendix D.

The effect of coastal development on shellfish-growing areas can be seen by the increasing acreage adversely affected by development-related pollution sources from 1985 to 1990. For example, the largest increases are attributed to urban runoff, increasing from 23 to 38 percent of harvest-

limited waters. The acreage adversely affected by septic systems increased from 22 percent to 37 percent. Pollution from septic systems is associated with continuing growth in tourism and vacation home development. Also indicative of accelerating pressures from coastal recreation is the increase in waters adversely affected by boating, up from 11 to 18 percent.

Recent Trends in Landings. Figure 2 shows landings between 1985 and 1989 for the four major species harvested in each region. Data by state are presented in Appendix E. In all regions, commercial harvests declined. By the end of 1990, Gulf of Mexico oyster landings fell to 10.6 million pounds, making the Pacific region the leading producer at 10.8 million pounds.

A notable exception to declines is the increase in landings of scallops (non-estuarine) along the Atlantic Coast. This increase generally is attributed to declines in estuarine abundance which has forced many fishermen to harvest offshore areas, and to recent fishing agreements between the U.S. and Canada. Pacific oyster landings have also increased slightly as a result of successful aquaculture.

Commercial Harvest. Over the last three decades, commercial stocks of wild estuarine shellfish have continued to decline nationwide despite restoration efforts such as oyster reef replenishment, hatchery operations, and selective breeding. For example, Chesapeake Bay produced more than 32 million pounds of oysters annually until about 1959 when a sharp decline began. By 1989, only four million pounds were harvested from the Bay, and in 1990 this dropped further to 3.7 million pounds.

Even with an increase in aquaculture, the American shellfishing industry seems no longer able to meet the Nation's demand for shellfish products. Oyster imports increased from 21 million pounds in 1970 to 46 million pounds in 1988, and other species show similar trends (Virginia Sea Grant College Program, 1990). Despite price increases, the actual value of all U.S. landings of oysters, clams, and scallops has decreased (in constant dollars) from $368 million in 1985 to $360 million in 1989 (National Marine Fisheries Service, 1985; National Marine Fisheries Service, 1990).

Recreational Harvest. In 1985, about four million adults participated in recreational shellfishing for crustaceans and mollusks nationwide (NOAA, 1991a). This added up to over 28 million person-days of recreational shellfishing activities. Though data are not available on landings, some states estimated that recreational landings were higher than commercial landings. Over one-fifth of the fish and shellfish consumed nationwide is derived from recreational or subsistence fishing (National Academy of Sciences, 1991). This high level of participation concerns State and Federal officials because they do not have the resources to monitor recreational fishing waters adequately.

Major Causes of Declines in Landings. Despite long-standing evidence supporting greater restraint, overharvest remains a significant cause of decline in natural shellfish stocks (Kennedy, 1983). Disease and pollution are also major concerns among natural harvesters and aquaculturists. For example, after MSX and Dermo reduced oyster populations in Chesapeake Bay, traditional seed beds in the James and Choptank rivers were opened. This placed the remaining harvestable population at risk of being entirely eliminated (Hargis and Haven, 1988).

Disease. Beginning in the 1950s, the parasitic diseases MSX and Dermo attacked oyster populations along the Atlantic and Gulf coasts. Since 1957, many significant mortalities have occurred, especially during periods of drought and high salinity. Entire populations have been wiped out in several estuaries. There has been some success in producing MSX-resistant strains through selective breeding, but these strains were not resistant to Dermo in Chesapeake Bay (Ford, pers. comm.). In recent studies of shellfish mortality, viruses have also been found as causative agents (Comps, 1988). Preliminary findings suggest that the ability of shellfish to withstand such infections is compromised by environmental pollutant stresses (Anderson, 1988).

Pollution. Harvest areas are classified as approved if pollution levels are below minimum coliform standards. Many states reported that areas containing harvestable stock (or which have the potential for aquaculture, especially on the Pacific Coast) were closed or downgraded due to bacterial levels or the lack of supporting sampling data. In addition, shellfish continue to be routinely stressed by low oxygen events caused by nutrient inputs from urban and rural sources (Chesapeake Executive Council, 1989). Chemical contaminants cause direct damage to shellfish, including death and reduced recruitment (Bender and Huggett, 1988). Improved shellfish management and replenishment programs are not likely to overcome these problems, and aquaculturists may not be able to use

Table 6. *Status of Shellfish Management Programs, 1990* [a]

State	Areas Managed	Acres Classified (x1,000)	Acres Sampled (%)	Acres/ Sampling Station
Maine	285	902	90	714
New Hampshire	30	14	90	481
Massachusetts	371	307	100	3,474
Rhode Island	78	136	100	567
Connecticut	131	358	100	888
New York	166	1,077	85	718
New Jersey	251	403	100	167
Delaware	39	231	25	1,686
Maryland	226	1,375	100	1,937
Virginia	269	1,575	100	788
North Carolina	232	2,287	100	1,610
South Carolina	86	279	100	775
Georgia	44	169	100	740
Florida	298	1,206	100	969
Alabama	10	371	100	4,818
Mississippi	38	434	100	3,122
Louisiana	180	3,394	80	4,243
Texas	96	1,898	90	2,751
California	112	130	5	2,150
Oregon	43	36	80	367
Washington	139	262	100	33
Total	**3,124**	**16,844**	**92**	**1,571**

a. Estuarine shellfish-growing waters only.

the natural waters directly without significant improvements in overall estuarine water quality (Costagna, 1987).

State Programs

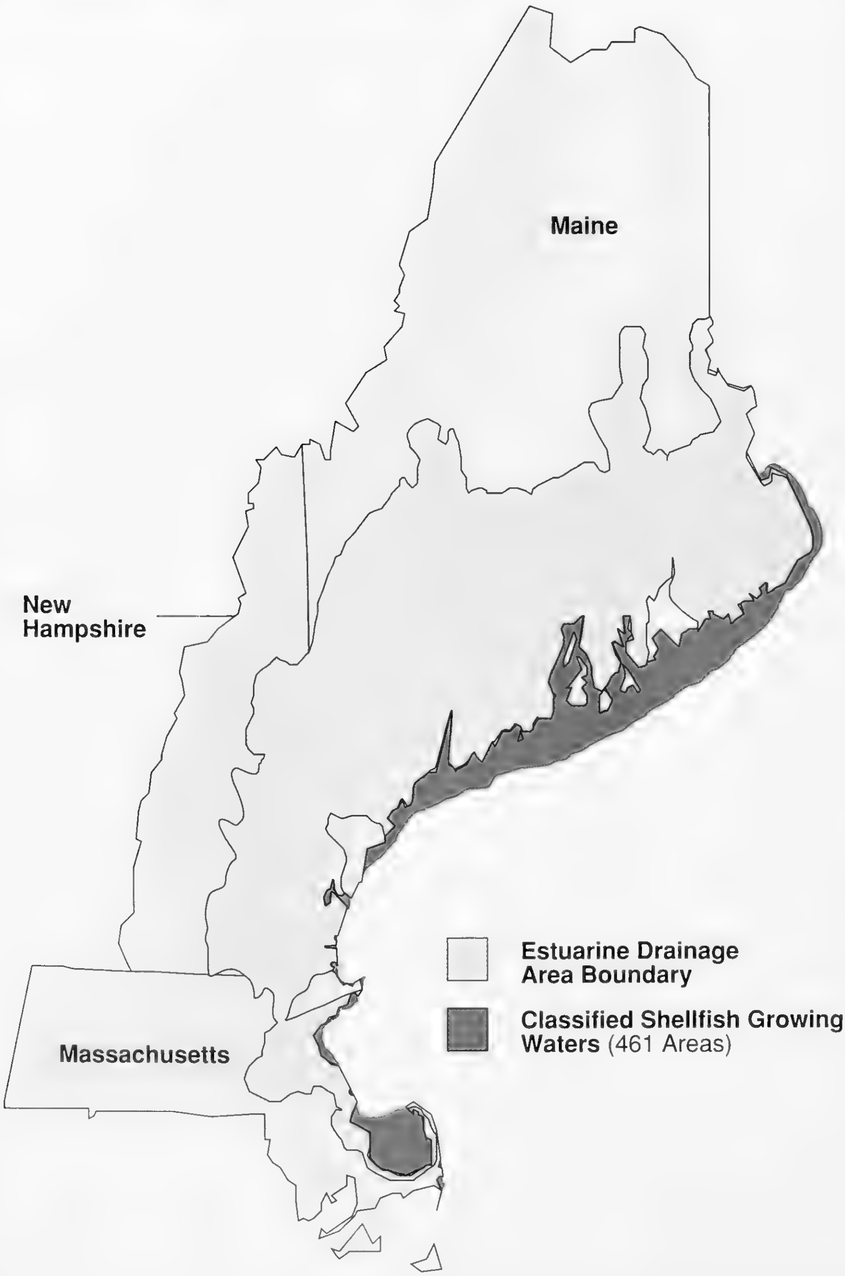
The data compiled in the Register are primarily a synthesis of the information and knowledge accumulated on an almost daily basis by State shellfish management agencies. Consequently, the quality of data presented is directly related to the resources available to conduct shellfish management responsibilities. Since State resources vary, the availability and detail of shellfish-related information varies. For example, sampling station density ranges from just 33 acres per station in Washington to 5,288 acres per station in Louisiana. Table 6 shows how shellfish-producing states compare in acres managed and survey and sampling activities. Appendix F provides data on budgets and sampling stations.

Shellfish-growing waters classified as conditionally approved require the most management resources. These areas are opened or closed on the basis of rainfall or river stage established in a current FDA-certified plan. Plans for conditionally approved areas must be updated and supported by extensive sampling. Areas classified as approved do not require a management plan but do require sampling. State budget shortfalls usually lead first to a curtailment of field sampling and then to administrative downgrades in many conditionally approved (or even approved) areas.

Conditionally approved areas are often the most productive, and closing such areas typically reduces landings. The 11 states which had no budget increase between 1985 and 1990 (Appendix F) manage about 45 percent of the Nation's approved and conditionally approved acreage, and also produce about 45 percent of the Nation's total value of shellfish harvest.

Each year since 1985 the Interstate Shellfish Sanitation Conference has expanded the NSSP regulatory guidelines that define the responsibilities of State shellfish management programs. In addition, the Congress is considering mandatory seafood inspection requirements. Given budget trends in State shellfish programs since 1985, many states may not have adequate resources to keep up with these expanding regulatory demands. This could lead to further administrative reductions in approved and conditionally approved harvesting areas.

Figure 3. *Classified Shellfish-Growing Waters, 1990*



In the North Atlantic region, 1.1 million acres of estuarine waters were classified for shellfish harvest in 1990 (Figure 3). This region experienced the largest decrease in percentage of approved estuarine shellfish-growing waters nationwide, from 88 percent in 1985 to 69 percent in 1990. In addition, Maine classified over 884,000 acres offshore, all approved, and Massachusetts classified over 394,000 acres offshore, of which 349,000 were approved.

Estuarine Shellfish-Growing Waters. The North Atlantic region extends from the U.S.-Canada border in Maine to the tip of Cape Cod in Massachusetts. Estuaries in the region are small, deep, and subject to strong tidal forces. There are only about 1,200 square miles of coastal wetlands in the region (NOAA, 1991b). Consequently, habitat for intertidal molluscan shellfish is limited while habitat for subtidal species such as scallops is excellent. The estuarine water surface areas range from six square miles for the Merrimack River to 548 square miles for Cape Cod Bay. Five of the drainage basins that most directly affect the quality of the region's shellfish-growing waters are dominated by metropolitan areas; the rest are largely rural, agricultural and forested (NOAA, 1990). Penobscot Bay has the most approved shellfish-growing waters, 215,000 acres, followed by Casco Bay, with 113,000 acres. Appendix C identifies the estuaries in the region and summarizes the status of shellfish-growing waters in each.

Classified Shellfish-Growing Waters, 1985-1990. Approved estuarine shellfish-growing waters declined from 88 to 69 percent of classified estuarine waters between 1985 and 1990. Over 352,000 acres in the region are now classified as harvest-limited. In addition, a net of 10,000 non-productive acres were removed from the Register data base. Declines in approved waters occurred in Maine and Massachusetts, and resulted in 219,000 acres being downgraded to harvest-limited classifications. However, nearly 1.3 million approved acres were added offshore. Table 7 shows classifications by state for 1985 and 1990.

Eight of the 15 estuaries in the region had downgrades in classification of shellfish-growing waters, while five had upgrades. Approved acreage outside estuaries in NOAA's NEI increased by 8,000 acres. However, downgrades occurred in Passamaquoddy, Englishman,

Table 7. *Distribution of North Atlantic Classified Estuarine Waters, 1985 and 1990*

	Percent Classified							
	Approved		Prohibited		Conditional		Restricted	
State	85	90	85	90	85	90	85	90
ME	90	78	8	22	1	1	1	>1
NH	34	34	55	15	0	0	11	52
MA	70	36	25	62	<1	1	5	1
Total	**88**	**69**	**10**	**29**	**1**	**1**	**2**	**1**

Table 8. *North Atlantic Pollution Sources Affecting Harvest-Limited Acreage, 1990* [a,b]

Sources	Maine Acres	Maine %	New Hampshire Acres	New Hampshire %	Massachusetts Acres	Massachusetts %
Point Sources						
Sewage Treat Plants	115	*57*	9	*100*	120	*85*
Combined Sewers	0	*0*	1	*11*	21	*15*
Direct Discharge	0	*0*	0	*0*	1	*1*
Industry	11	*5*	4	*44*	9	*6*
Nonpoint Sources						
Septic Systems	82	*40*	2	*22*	7	*5*
Urban Runoff	24	*12*	6	*67*	50	*36*
Agricultural Runoff	0	*0*	6	*67*	5	*4*
Wildlife	0	*0*	6	*67*	19	*14*
Boats	17	*8*	5	*56*	38	*22*
Upstream Sources						
Sewage Treat Plants	0	*0*	0	*0*	2	*1*
Combined Sewer	0	*0*	0	*0*	0	*0*
Urban Runoff	0	*0*	0	*0*	3	*2*
Agricultural Runoff	0	*0*	0	*0*	0	*0*
Wildlife	0	*0*	0	*0*	0	*0*

a. Acres are times 1,000; % is percent of all harvest-limited acreage in state.
b. Since the same percentage of a shellfish area can be affected by more than one source, the percentages shown above cannot be added. They will not sum to 100.

Narraguagas, Penobscot, Casco, Saco, Boston, and Cape Cod bays. In seven estuaries, additional acres were classified. The majority of these were prohibited acres in Penobscot, Frenchman, Massachusetts, and Cape Cod bays, because most of the additional acres were classified as prohibited.

Most classification changes in Maine and Massachusetts were a result of management decisions based on increased sanitary survey and sampling activities. Significant water quality declines occurred in Hampton, Little, and Rye harbors, and Cape Cod Bay, and significant upgrades occurred in the Winnicut, Oyster, and Bellamy rivers, and Little Bay.

Pollution Sources Affecting Shellfish-Growing Waters. The pollution sources affecting North Atlantic shellfish-growing waters reflect the region's high population density in areas such as Boston Bay, in contrast to low population density in areas such as Passamaquoddy Bay. Table 8 shows the major categories of pollution sources affecting the harvest-limited waters in the North Atlantic region. Data on pollution sources by estuary are provided in Appendix D.

Sewage treatment plants affect 67 percent of harvest-limited areas. However, the region has the smallest number of point source dischargers, about 400. Of these, 59 are found in Great Bay and 69 in Boston Bay. The metropolitan area of Boston, with a population of over 2.5 million, impacts shellfish-growing waters in both Boston and Massachusetts bays. Sewage treatment plants affect the most shellfish-growing waters, followed by *septic systems, industry,* and *urban runoff.* In 1988, highly productive shellfish-growing waters (approximately $315,000 annual harvest) were closed in Boston Bay because of major malfunctions in the area's overloaded sewage treatment plants. Boston has since begun construction

of a $6.1 billion plant as a corrective measure.

In New Hampshire, all harvest-limited waters are affected by sewage treatment plants. However, harvest-limited waters are also significantly affected by industry (44 percent) and *agricultural runoff* (67 percent). The effects of these sources have required the State to close or restrict 64 percent of its classified shellfish-growing waters.

In contrast, pollution from septic systems affects almost as much harvest-limited waters (40 percent) in Maine as do sewage treatment plants (57 percent). Shellfish-growing waters in all but one of Maine's eight estuaries are affected by septic effluent. As a result, towns have adopted discharge ordinances that restrict development in low-lying coastal areas. Developers in such places must add sand filtration and chlorination to their septic systems. After 1992, any system that pollutes shellfish-growing waters will be shut down by the State.

Landings

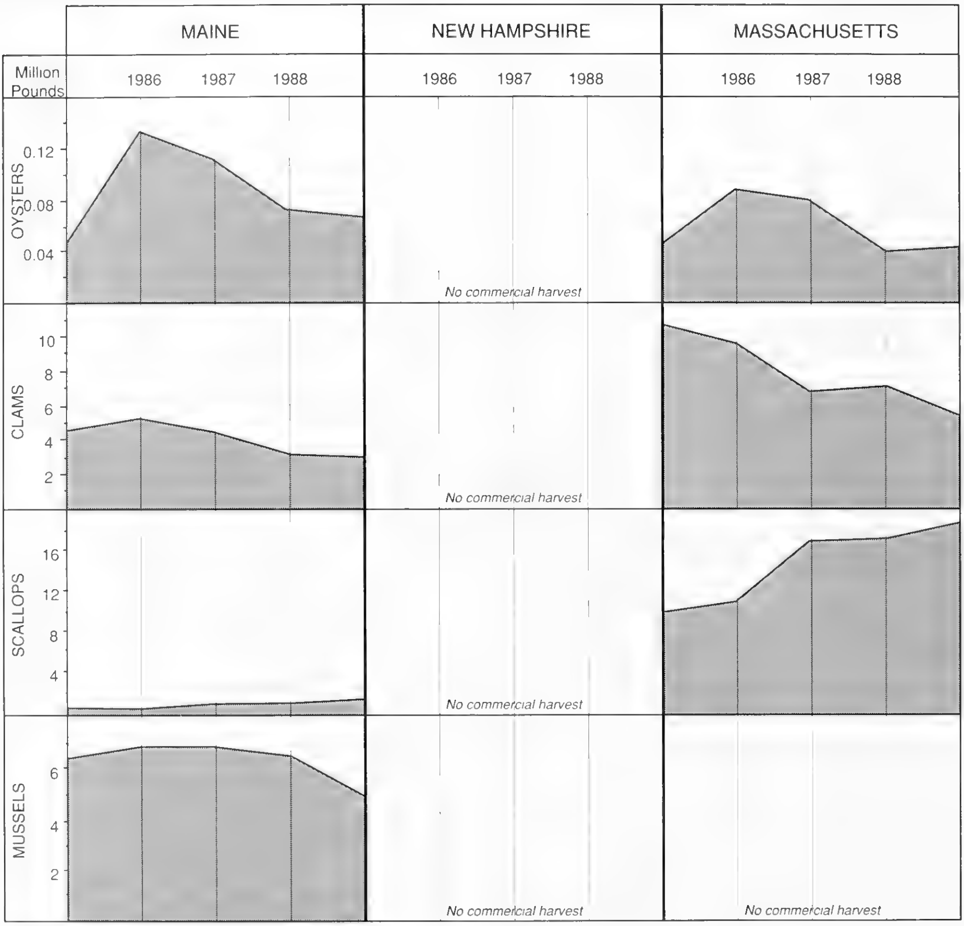
The region's harvest has declined dramatically since the 1950s. Oyster landings dropped from 219,000 pounds in 1986 to 113,000 pounds in 1989. Clam landings dropped from 14.6 million to 8.3 million pounds, and mussel landings dropped from 6.6 million pounds to 4.8 million pounds. The exception is the scallop harvest, which increased from 11.7 million to 20.3 million pounds as a result of offshore fishing agreements with Canada. Figure 4 shows landings in millions of pounds of meats for the principal harvested species for the three states in the region.

Landings by State. Oyster landings have been sporadic in *Maine*, rising from 49,000 pounds in 1985 to 138,000 pounds in 1986, and declining to 69,000 pounds in 1989. Clam landings declined from 4.5 million pounds to less than three million pounds. Over-harvesting and the closing of polluted shellfish-growing waters have contributed to this decline. Maine's scallop harvest increased from 813,000 pounds in 1985 to 1.7 million pounds in 1989.

The State classified over 884,000 acres of offshore waters, and was the first to establish a plan for managing episodes of marine biotoxins. Maine estimates that the closings imposed under the plan reduce harvest earnings by about seven million dollars annually (Shumway et al., 1988). In recent years, the occurrence of blooms has increased temporally and geographically. Closures from biotoxins have extended into surf clam and mussel-harvesting areas.

There have been no commercial harvests in *New Hampshire* since 1986. Only recreational harvest is allowed in approved shellfish-growing waters. The State estimates that downgrades of shellfish-growing waters and harvest restrictions over the last 20 years have resulted in an 85 percent loss in harvestable softshell clams and a 67 percent loss in harvestable oysters (Seiforth, pers. comm.).

Figure 4. *North Atlantic Commercial Shellfish Landings for Selected Species, 1985-1989*



Oyster landings, though sporadic, generally declined in *Massachusetts* from 87,000 pounds in 1986 to 44,000 pounds in 1989. Some of this decline resulted from the closure of the Taunton River to all shellfish harvesting. To mitigate this closure, the State supervises a relay program which moves clams from the Taunton River to approved areas in Cape Cod Bay. These clams are monitored for toxic chemicals as well as for coliform bacteria. Nevertheless, clam landings declined by almost 50 percent from 9.5 million pounds to 5.4 million pounds. This resulted, in part, from the closure of several large shellfish-growing areas in Boston and Massachusetts bays. Mussel landings from aquaculture operations and from Nantucket Shoals were minimal.

Massachusetts also had a large increase in scallop harvest, primarily

Recreational clam digging on the tidal flats of Maine is an important tradition and a concern to public health officials.

Courtesy of Robert E. Glika, National Geographic Society

from newly classified offshore shellfish-growing waters totaling 394,000 acres. Landings increased from almost 10 million pounds to over 18.5 million pounds between 1985 and 1990.

Middle Atlantic

Figure 5. *Classified Shellfish-Growing Waters, 1990*

In the Middle Atlantic region, 5.3 million acres of estuarine waters were classified for shellfish harvest in 1990 (Figure 5). Over 79 percent were approved and 21 percent were harvest-limited. In addition, New Jersey classified 265,000 acres of offshore waters, 78 percent of which were approved. This region ranks highest in the Nation in both quantity of classified and percentage of approved waters.

Estuarine Shellfish-Growing Waters. The Middle Atlantic region extends from Buzzards Bay in Massachusetts through Chesapeake Bay in Virginia. The region's coastal plain estuaries are shallow and subject to strong tidal circulation, creating an ideal habitat for molluscan shellfish. Consequently, this region contains more estuarine shellfish-growing waters (4.2 million acres) than any other. The region's estuaries vary in size from a surface water area of 32 square miles for the Delaware Inland Bays to 3,800 square miles for Chesapeake Bay. The drainage basins directly affecting the quality of shellfish-growing waters are relatively densely populated and contain large amounts of urban land (NOAA, 1990). Chesapeake Bay has the region's largest drainage area, greatest freshwater inflow, and contains the most wetlands. Nearly half of all approved shellfish-growing waters in the region are in the Bay. Appendix C identifies the estuaries in the region and summarizes the status of shellfish-growing waters in each.

Classified Shellfish-Growing Waters, 1985-1990. Approved shellfish-growing waters in the region declined from 82 percent of classified waters in 1985 to 79 percent in 1990. Downgrades occurred in all but two states (New Jersey and Virginia), and resulted in an additional 156,000 acres being downgraded to harvest-limited classifications. Over one million acres are now classified as harvest-limited in the region. In addition, over 78,000 non-productive acres were removed from the Register data base. Table 9 shows classifications by state for 1985 and 1990.

Eleven of the 21 estuaries in the region had downgrades in classification of shellfish-growing waters, while five had upgrades. Approved acreage outside estuaries in NOAA's NEI declined by 26,000 acres. Declines

Table 9. *Distribution of Middle Atlantic Classified Estuarine Waters,1985 and 1990*

	Percent Classified							
	Approved		Prohibited		Conditional		Restricted	
State	85	90	85	90	85	90	85	90
MA	92	54	8	45	1	1	0	0
RI	71	69	14	12	15	15	0	4
CT	73	68	11	19	1	2	15	12
NY	75	75	19	17	7	8	0	0
NJ	59	60	31	30	5	5	5	6
DE	91	74	8	25	1	1	0	0
MD	96	91	4	3	0	5	1	1
VA	83	83	8	7	2	1	8	8
Total	**82**	**79**	**11**	**13**	**3**	**4**	**4**	**4**

Table 10. *Middle Atlantic Pollution Sources Affecting Harvest Limited-Acreage, 1990* [a,b]

Sources	Massa-chusetts Acres	%	Rhode Island Acres	%	Connect-icut Acres	%	New York Acres	%	New Jersey Acres	%	Delaware Acres	%	Maryland Acres	%	Virginia Acres	%
Point Sources																
Sewage Treat Plants	10	*11*	23	*55*	78	*68*	212	*79*	109	*67*	14	*23*	16	*13*	179	*68*
Combined Sewers	4	*5*	7	*17*	26	*23*	135	*50*	52	*32*	0	*0*	0	*0*	0	*0*
Direct Discharge	0	*0*	9	*21*	7	*6*	68	*25*	0	*0*	0	*0*	0	*0*	0	*0*
Industry	0	*0*	6	*14*	8	*7*	1	*<1*	32	*20*	3	*5*	6	*5*	167	*63*
Nonpoint Sources																
Septic Systems	8	*9*	2	*5*	7	*6*	11	*4*	34	*21*	4	*7*	32	*26*	25	*9*
Urban Runoff	11	*13*	7	*17*	61	*54*	250	*93*	121	*74*	5	*8*	38	*31*	162	*61*
Agricultural Runoff	0	*0*	1	*2*	2	*2*	5	*2*	23	*14*	11	*18*	60	*49*	28	*11*
Wildlife	8	*9*	0	*0*	5	*4*	11	*4*	32	*20*	15	*25*	40	*33*	1	*<1*
Boats	7	*8*	16	*38*	48	*42*	32	*12*	62	*38*	0	*0*	15	*12*	173	*66*
Upstream Sources																
Sewage Treat Plants	11	*13*	11	*26*	51	*45*	0	*0*	5	*3*	0	*0*	0	*0*	26	*10*
Combined Sewer	0	*0*	0	*0*	3	*<1*	0	*0*	2	*<1*	0	*0*	0	*0*	<1	*<1*
Urban Runoff	10	*11*	17	*40*	9	*8*	0	*0*	5	*3*	0	*0*	5	*4*	26	*10*
Agricultural Runoff	0	*0*	0	*0*	0	*0*	0	*0*	1	*1*	0	*0*	0	*0*	0	*0*
Wildlife	10	*11*	0	*0*	2	*2*	0	*0*	0	*0*	0	*0*	0	*0*	16	*6*

a. Acres are times 1,000; % is percent of all harvest-limited acreage in state.

b. Since the same percentage of a shellfish area can be affected by more than one source, the percentages shown above cannot be added. They will not sum to 100.

took place in Buzzards, Great South, Delaware, and Chesapeake bays, and the Potomac, Chester, and Choptank rivers. Declines were particularly significant in the latter two rivers which contain Maryland's major oyster seed beds. However, Virginia's major seed-producing area, the James River, had an increase of over 11,000 acres of approved waters, almost all upgraded from conditionally approved status.

All states except Delaware conducted sanitary surveys and reclassification activities between 1985 and 1990 that resulted in slight increases in conditionally approved waters. In Maryland, 63,000 acres were reclassified from approved to conditionally approved during the period. New Jersey was the only state to upgrade its estuarine shellfish-growing waters primarily on the basis of improved water quality resulting from the construction of new regional sewage treatment plants and ocean outfalls.

However, the State must now monitor and classify offshore buffer areas near outfalls.

Pollution Sources Affecting Shellfish-Growing Waters. Many of the pollution sources affecting Middle Atlantic shellfish-growing waters reflect expanding urbanization in the region. Table 10 shows the major categories of pollution sources affecting harvest-limited waters in Middle Atlantic states. Both *sewage treatment plants* and *urban runoff* affected about 57 percent of the harvest-limited areas. About 2,700 point source dischargers are located in the region. This represents about 31 percent of all point source discharges in the Nation's coastal zone. Of the 900 municipal wastewater treatment plants in the region, 61 percent are in the Hudson River/ Raritan Bay and Chesapeake Bay estuarine drainage areas (NOAA, 1990). Data on pollution sources by estuary are provided in Appendix D.

Continued growth of the region's coastal population and an increasing demand for *coastal recreation* has resulted in an increase in marina construction since 1985 (Judy, pers. comm.). As a result, 31 percent of harvest-limited areas in the region are affected by *boating activities*. The greatest increases in affected acreage were in Chesapeake Bay and Long Island Sound.

Although *agricultural runoff* affected only 12 percent of all harvest-limited acreage, it has been associated with eutrophication events in many of the region's estuaries (Fisher, 1989). These events and the associated hypoxic conditions adversely affect the disease-resistance capabilities of shellfish, and have resulted in reductions in natural stocks (Anderson, 1988).

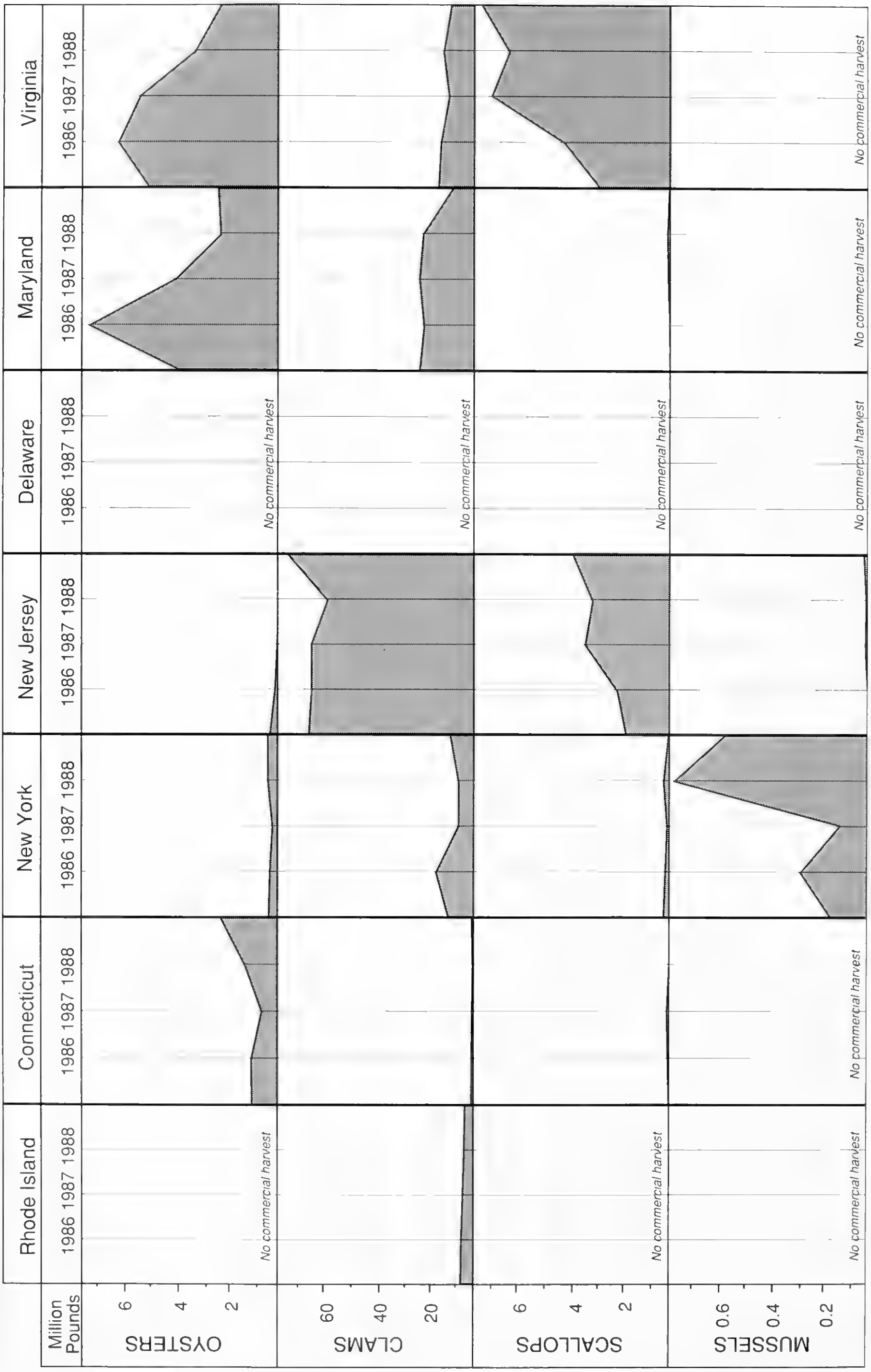
Industry, faulty *septic systems*, and *wildlife* also contribute to the closure or restriction of shellfish-growing waters. Large quantities of pesticides applied to agricultural lands in several Middle Atlantic estuaries, along with other toxic discharges from industry and urban runoff also affect many shellfishing areas (Costagna, 1988).

In New Jersey, the removal of point source sewage pollution from inland bays revealed that pollution from nonpoint sources also contributes significantly to harvest limitations.

Landings

As recently as 1959, the Middle Atlantic region led the Nation in the harvest of oysters, and in total molluscan shellfish landings. However, since then, increasing urban pollution has closed many of the historically productive areas in Raritan Bay, Long Island Sound, and Narragansett Bay. Over-harvesting, eutrophication, and disease have also destroyed many other formerly productive estuarine shellfishing areas. Consequently, declines in the overall landings of estuarine shellfish continued between 1985 and 1990, despite increased aquaculture. Figure 6 shows landings in millions of pounds of meats of the principal harvested species in the six major producing states in the region.

Figure 6. Middle Atlantic Commercial Shellfish Landings for Selected Species, 1985-1989



Landings by Major Bays. Over 32 million pounds of oysters were harvested annually in *Chesapeake Bay* until 1959, when a major decline began. MSX and Dermo were the major causes of the loss (Ford, pers. comm.). By 1989, landings were only about four million pounds. This decline has affected the ecology of the Bay and has impacted other fisheries as well (Hargis and Haven, 1988; Chesapeake Executive Council, 1989).

Delaware Bay experienced a similar decline in oysters due to MSX beginning in 1957. By the early 1970s, harvest was at an all-time low. However, after Hurricane Agnes in 1972 the oyster population recovered, only to be decimated again by MSX in the early 1980s (Ford, pers. comm.). Over 640,000 pounds were landed in the Bay in 1980, declining dramatically to 39,000 pounds in 1985. There was no significant harvest in 1989. Reef restoration has been unsuccessful, although several northern beds may recover in the 1991 season (Cole, pers. comm.). Clam landings in the Bay also declined from over 500,000 pounds in 1985 to only 37,000 pounds in 1989. Declining harvest is complicated further by the closure of many shellfishing areas pending sufficient resources to conduct sanitary surveys.

Landings by State. Buzzards Bay is the only major *Massachusetts* shellfishing area in this region. However, landings are low compared to other Middle Atlantic estuaries. Oyster landings in the Bay fluctuated between 18,000 and 33,000 pounds between 1985 and 1989.

Only about 2,000 pounds of oysters were landed annually between 1985 and 1989 in *Rhode Island.* Clam landings declined from about six million to just over four million pounds during the same period. Scallop landings declined from 22,000 pounds in 1985 to zero in 1986 because of brown tide infections, and have not been reestablished.

A new management program has begun to revitalize the shellfish industry in *Connecticut.* The State legislature provided significant funds for reef restoration and regulatory program expansion. The industry is allowed to relay juvenile oysters from public grounds classified as restricted to private leases in approved waters. The program has also further stimulated aquaculture operations. Oyster landings increased from less than one million to almost two million pounds between 1985 and 1989. Over the same period, clam landings declined from 845,000 pounds to 710,000 pounds. In 1987 a brown tide seriously affected scallop harvest, reducing landings to 130,000 pounds.

Aquaculture has sustained the oyster industry in *New York*, increasing landings from almost 299,000 pounds to 339,000 pounds between 1985 and 1989. However, the largest New York producer recently reported massive mortalities in one of its growing areas. Viral disease is suspected (Relyea, pers. comm.).

Bay scallop landings in New York declined from 269,000 pounds in 1985 to about 40,000 pounds in 1989, following a brown tide. However,

State officials expect the population to recover over the next two years. New York has the only sizeable mussel production in the region; landings increased from 154,000 pounds in 1985 to 585,000 pounds in 1989. With the support of 15 hatcheries, clam landings, primarily in Great South Bay, remain at about nine million pounds per year.

New Jersey offshore waters provided the largest harvest of surf clams and ocean quahogs in the region, totaling over 71 million pounds in 1989. New Jersey currently has 10 hard clam hatcheries and 30 growers, which should increase the hard clam landings in the near future. Scallop landings from offshore harvest increased from 1.7 million to almost four million pounds between 1985 and 1989.

Although consumer demands for *Maryland* clams increased during the 1980s, landings decreased from 23 million pounds to eight million pounds between 1985 and 1989.

Clam landings in *Virginia* declined from 14 million pounds in 1985 to nine million pounds in 1989. However, landings of scallops tripled to almost eight million pounds. This represents a trend away from declining estuarine species toward more abundant offshore species.

Only a few skipjacks remain, but are still the primary means of oyster dredging in the Maryland waters of Chesapeake Bay.

Courtesy of Emory Kristof, National Geographic Society

Figure 7. *Classified Shellfish-Growing Waters, 1990*

In the South Atlantic region, 2.9 million acres of estuarine waters were classified for shellfish harvesting in 1990. Over 71 percent were approved and 29 percent harvest-limited. This region ranks second in the Nation in percent of approved shellfish-growing waters, and third in percentage of approved waters.

Estuarine Shellfish-Growing Waters. The South Atlantic region extends from North Carolina to southern Florida. The estuaries of the region are shallow, and while they receive 40 percent of the freshwater inflow on the entire Atlantic Coast, they are more affected by wind-generated circulation than by tides or rivers (NOAA, 1990). Consequently, the estuaries are moderately to highly susceptible to pollution retention. This region ranks third in amount of estuarine water surface area, 4,443 square miles. Estuaries range in size from a surface water area of nine square miles for the North and South Santee rivers to 2,949 square miles for Albemarle/Pamlico Sounds. The latter contains over half of the region's approved shellfish-growing waters. In both size and approved shellfish-growing waters, the Albemarle/Pamlico Sounds estuary is second nationwide only to Chesapeake Bay. South Atlantic estuarine drainage areas (EDAs) contain nearly 5.9 million acres of coastal wetlands, second only to the Gulf of Mexico, including the productive sea islands complex of channels and marshlands in South Carolina and Georgia. Sixteen of the 18 EDAs in the region are dominated by forests. Appendix C identifies the estuaries in the region and summarizes the status of shellfish-growing waters in each.

Classified Shellfish-Growing Waters, 1985-1990. The South Atlantic region had the smallest net change in classification and the smallest net loss of approved waters between 1985 and 1990. Although classification changes took place in 12 of the region's 18 estuaries, the net change was only 140,000 acres. Of this net change, 5,000 acres were downgrades in previously approved shellfish-growing waters, and 135,000 acres were additions to the classification system (primarily in the restricted classification) from previously unclassified waters.

The South Atlantic led all regions in additional acreage classified as restricted. Florida added 65,000 restricted acres to support increases in relaying and depuration operations. Similarly, South Carolina added

Table 11. *Distribution of South Atlantic Classified Estuarine Waters, 1985 and 1990*

	Percent Classified							
	Approved		Prohibited		Conditional		Restricted	
State	85	90	85	90	85	90	85	90
NC	80	79	18	19	2	2	0	<1
SC	72	69	24	17	3	3	0	11
GA	31	28	61	68	0	0	9	3
FL	35	19	32	20	33	30	<1	31
Total	**75**	**71**	**22**	**21**	**3**	**4**	**1**	**3**

Table 12. *South Atlantic Pollution Sources Affecting Harvest-Limited Acreage, 1990* [a,b]

	North Carolina		South Carolina		Georgia		Florida	
	Acres	%	Acres	%	Acres	%	Acres	%
Point Sources								
Sewage Treat Plants	167	*35*	47	*54*	38	*31*	122	*73*
Combined Sewers	0	*0*	0	*0*	0	*0*	0	*0*
Direct Discharge	0	*0*	0	*0*	5	*4*	0	*0*
Industry	83	*17*	46	*53*	43	*36*	8	*5*
Nonpoint Sources								
Septic Systems	57	*12*	22	*25*	48	*40*	161	*96*
Urban Runoff	77	*16*	39	*45*	34	*28*	140	*84*
Agricultural Runoff	222	*47*	3	*3*	8	*7*	0	*0*
Wildlife	149	*31*	17	*20*	42	*35*	98	*59*
Boats	64	*13*	30	*34*	37	*31*	15	*9*
Upstream Sources								
Sewage Treat Plants	0	*0*	7	*8*	2	*2*	0	*0*
Combined Sewer	0	*0*	0	*0*	0	*0*	0	*0*
Urban Runoff	0	*0*	6	*7*	2	*2*	0	*0*
Agricultural Runoff	0	*0*	0	*0*	0	*0*	0	*0*
Wildlife	0	*0*	19	*22*	16	*13*	0	*0*

a. Acres are times 1,000; % is percent of all harvest-limited acreage in state.

b. Since the same percentage of a shellfish area can be affected by more than one source, the percentages shown above cannot be added. They will not sum to 100.

30,000 restricted acres for relaying purposes. North Carolina classified 1,000 additional acres as restricted. Table 11 shows classifications by state for 1985 and 1990 in the region.

Increased sanitary surveys and sampling activities throughout the region resulted in the addition of 37,000 conditionally approved acres, the second largest regional gain in the Nation.

Five of the 17 estuaries with classified shellfish-growing waters had downgrades, five had upgrades, and seven had no change. Approved acreage outside estuaries in NOAA's NEI increased by 31,000 acres. Major declines occurred in the Neuse River, the North and South Santee rivers, and St. Helena and St. Catherines/ Sapelo Sounds. Florida's Indian River estuary had the largest increase in classified waters. About 26,000 conditionally approved acres and 57,000 restricted acres were added to

the estuary from previously unclassified waters. This addition was the result of more intensive monitoring by the State, as well as the emergence of intensive clam culture within the estuary.

Many South Carolina estuaries had changes in classified acreage. In response to the growing clam culture, the State increased its survey and monitoring activities. As a result, 16,000 additional acres were classified as restricted in the Santee River and Charleston Harbor. St. Helena Sound had the largest decrease in approved waters, and 28 percent of the estuary's shellfish-growing waters were removed entirely from the Register data base as a result of over-harvesting and habitat loss.

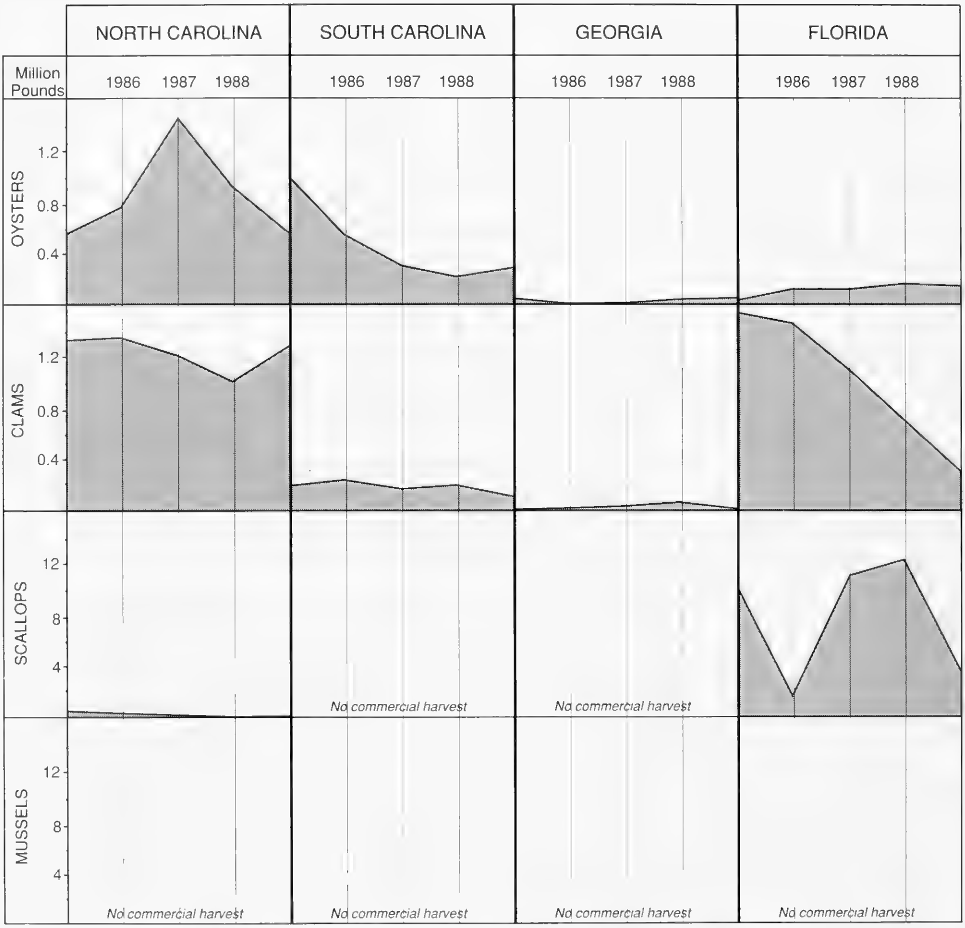
Pollution Sources Affecting Shellfish-Growing Waters. The pollution sources affecting South Atlantic shellfish-growing waters reflect the generally low population density across the region, the growth in tourism and second home development, and the presence of several major urban areas such as Wilmington, Charleston, Savannah, and Jacksonville. Table 12 shows the major categories of pollution sources affecting the harvest-limited waters in the South Atlantic region. Data on pollution sources by estuary are provided in Appendix D.

Sewage treatment plants affect 44 percent of the harvest-limited waters. The South Atlantic region ranks third in the Nation in the number of sewage treatment plants. They affect 14 of the 17 estuaries with shellfish-growing waters. As a result of intense population growth, more than half of the region's sewage treatment plants are found in Florida's Atlantic coast estuarine drainage areas. The natural harvest in these estuaries has been decimated, and harvest is recovering only through conservation and aquaculture. For example, although the St. Johns River estuary is the fourth largest in the region by surface water area (165,120 acres), only 4,291 acres are classified, and just 19 percent of these are approved for harvest.

Nonpoint sources of pollution had the greatest effect on shellfish-growing waters. These sources are the most difficult to control, and the effects are persistent because many of the estuaries have weak circulation. *Septic systems* and *urban runoff* each affect 34 percent of the harvest-limited waters, the second highest rates in the Nation after the Gulf of Mexico. Waters in 13 of the region's 17 estuaries containing shellfish-growing waters are affected by these sources. The South Atlantic region ranks first in the Nation in the percent of harvest-limited waters (17 percent) affected by *boating*. These nonpoint source effects reflect the impacts of growth in tourism, second home development, and seasonal population influx.

The South Atlantic ranked first among regions in the percentage of harvest-limited waters affected by *wildlife* (36 percent) and *agriculture* (28 percent). Shellfish officials are concerned about the effects of these pollution sources

Figure 8. *South Atlantic Commercial Shellfish Landings for Selected Species, 1985-1989*



on shellfish habitat as well as on public health. For example, the region has the greatest intensity of *pesticide application* to agricultural lands in the Nation (NOAA, 1990). Although human pathogens normally may not be associated with wildlife and agriculture, the nutrients and toxics from these sources do affect water quality and shellfish habitat. This is especially true in the South Atlantic because of weak estuarine circulation.

Landings

The region's landings declined dramatically between 1985 and 1989. Oyster landings declined from 1.6 million to one million pounds, clams declined from 3.1 million to 1.7 million pounds, and scallops from 10.4 million to 3.4 million pounds. No mussels were landed during this period, although South Carolina reported new

landings of two offshore species, blood arc and whelk. Figure 8 shows landings in millions of pounds of meats for the principal harvested species for the four states in the region.

Landings by Major Bays. *Albemarle/Pamlico Sounds* is the largest oyster-producing estuary in the South Atlantic region, and historically has been the source of 60 percent of all landings in North Carolina. Landings peaked at 1.4 million pounds in 1987 and declined to 530,000 pounds in 1989, due in part to MSX and Dermo. This suggests that the estuarine salinities varied abnormally during this period. Although the classifications of shellfish-growing waters did not change significantly, North Carolina expanded sampling because of rapidly expanding development.

In 1985, South Carolina's *Charleston Harbor, St. Helena Sound*, and *Broad River* estuaries combined to produce over 745,000 pounds of oysters, but only 75,000 pounds were landed in 1989. Like Albemarle/Pamlico Sounds, these estuaries were affected by MSX and Dermo, as well as red tide blooms from the dinoflagellate *Ptychodiscus brevis.* The decline also was influenced by over-harvesting and the net loss of 9,000 acres of approved shellfish-growing waters.

The *Indian River* estuary produced the largest landings of clams and scallops (calico) in the region, and nearly all landings of these species for the Atlantic coast of Florida. Clam landings for this estuary declined from 1.5 million pounds in 1985 to 306,000 pounds in 1989, due primarily to over-harvesting. Also, conditionally approved waters increased by 26,000 acres and restricted waters by 57,000 acres.

Landings by State. In *North Carolina*, oyster landings declined from 545,000 pounds in 1985 to 530,000 pounds in 1989, as a result of MSX, Dermo, and red tide bloom effects. Clam landings remained constant at 1.3 million pounds, while scallop landings declined from 456,000 pounds to 84,000 pounds. Three of the State's six estuaries had declines in approved shellfish-growing waters and three had increases. Four of the six had increases in conditionally approved waters. Consequently, the major reasons for declines were disease, over-harvesting, and habitat loss. Several new clam hatcheries have begun operations, and the State revised its leasing program in support of aquaculture initiatives. In September 1987, a bloom of the toxic dinoflagellate *Ptychodiscus brevis* occurred. The State closed 361,000 acres of shellfish-growing waters for three months between Cape Hatteras and the South Carolina border (48 percent of the State's oyster beds). The economic loss was estimated to be $3.5 million. Most of the affected areas were re-opened within three months.

Like many Atlantic Coast states, *South Carolina's* oyster industry has been damaged severely by a combination of over-harvesting, disease,

pollution, and habitat loss from coastal development. Oyster landings declined from one million pounds to 290,000 pounds between 1985 and 1989. Only two of the State's once numerous oyster-shucking houses remain. Clam landings fluctuated between 108,000 and 240,000 pounds. The State has just begun operations at the Nation's largest clam hatchery. No scallop or mussel landings were reported. Between January and May 1988, South Carolina closed over 4,600 acres of approved shellfish-growing waters after discovering the red tide in its northern waters. The State currently is planting shell to revitalize its oyster beds, and is encouraging aquaculture operations.

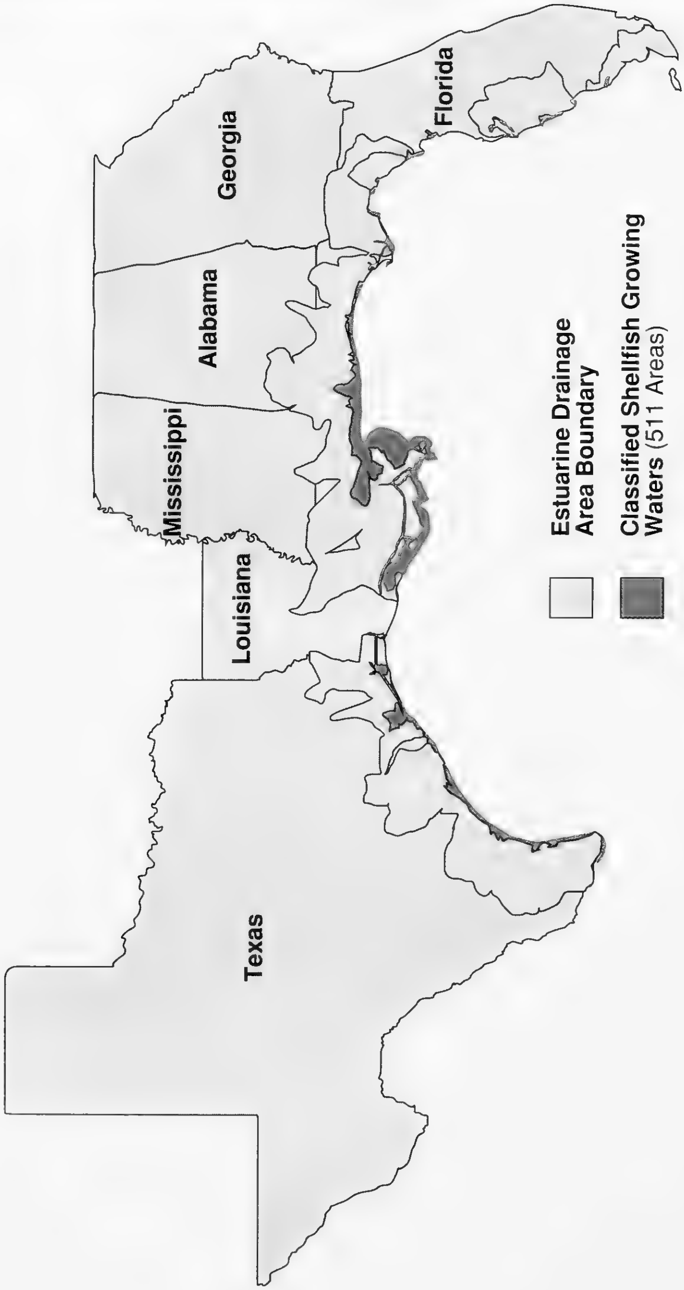
Georgia had the second smallest shellfish harvest in the Nation. In 1989, oyster landings reached their highest level in five years, 46,000 pounds. Although Georgia's estuarine waters are high in nutrients and are relatively clean, restrictions on dredging, access to reefs in tidal creeks, and the difficulty of removing oysters from large clumps has delayed development of the oyster industry. Leases for bid are rare because upland property owners' rights extend to the mean low water level, and all marsh lands are state-owned. In addition, the State's limited classification resources led to a policy that requires the closing of all shellfish-growing waters near urban areas. These same factors affect the clam harvest, which did not decline but varied greatly from 7,000 pounds to 64,000 pounds annually.

Oyster harvest in *Florida* increased from 28,000 to 134,000 pounds as a result of hatchery operations. The number of planted seed oysters produced in hatcheries increased from 16 million in 1988 to 74 million in 1990. The scallop harvest declined from 10 million to 3.4 million pounds. The historically substantial clam harvest also declined significantly, from 1.5 million pounds in 1985 to 300,000 pounds in 1989. Decreases in Indian River resulted primarily from over-harvesting. However, in the St. Johns River and Biscayne Bay estuaries, the decline resulted from pollution due to increases in urban population. Most of Biscayne Bay's shellfish-growing waters have been removed entirely from classification. Still, clam hatchery operations have recently been initiated in Indian River and Biscayne Bay.

Recreational harvest of intertidal oysters in inland creeks in Georgia.

Courtesy of Bates Littlehale, National Geographic Society

Figure 9. *Classified Shellfish-Growing Waters, 1990*



In the Gulf of Mexico region, 7.1 million acres of estuarine waters were classified for shellfish harvest in 1990 (Figure 9). Forty-eight percent were classified as approved and 52 percent as harvest-limited. This region ranks first in the Nation in both total acres of classified estuarine shellfish-growing waters and total acres of prohibited shellfish-growing waters.

Estuarine Shellfish-Growing Waters. The Gulf of Mexico region extends from the southern tip of Florida, west to the Texas-Mexico border. Estuaries in the region are generally the shallowest in the Nation, have the largest amount of water surface area (11,764 square miles), receive the greatest freshwater inflow, and are the least influenced by tidal circulation. The Gulf of Mexico contains the most classified shellfish-growing waters (7.1 million acres) in the Nation, and was the largest oyster-producing region. The region also contains more than half of the Nation's coastal wetlands (16,600 square miles), and is generally the least susceptible to pollution retention.

Gulf of Mexico estuarine drainage areas (EDAs) are strongly affected by hurricanes and rainfall, creating extremes in circulation, salinity, and upstream influences in the estuaries (NOAA, 1990). Therefore, the region contains 73 percent (1.2 million acres) of the Nation's conditionally approved shellfish-growing waters. Appendix C identifies the estuaries in the region and summarizes the status of shellfish-growing waters in each.

Classified Shellfish-Growing Waters, 1985-1990. Approved shellfishing areas in the region declined from 54 percent of classified waters in 1985 to 48 percent in 1990. Over 3.7 million acres now are classified as harvest-limited. In addition, almost 147,000 acres were removed from the Register data base. Declines in approved acreage occurred in Florida and Texas, while Mississippi and Louisiana gained approved acreage. Alabama had no change in approved acreage, but added 17,000 acres, all classified as prohibited. Table 13 shows classifications by state for 1985 and 1990.

Fourteen of the 32 estuaries had net downgrades in classification while eight had upgrades. Ten estuaries had no net change in classification. Approved acreage outside estuaries in NOAA's NEI increased by 14,000 acres. Particularly significant were the reclassifications from conditionally

Table 13. *Distribution of Gulf of Mexico Classified Estuarine Waters, 1985 and 1990*

	Percent Classified							
	Approved		Prohibited		Conditional		Restricted	
State	85	90	85	90	85	90	85	90
FL	28	15	33	35	39	43	0	5
AL	16	15	24	28	60	57	0	0
MS	35	64	25	15	40	8	1	13
LA	52	56	24	35	13	10	11	0
TX	80	56	20	37	<1	7	0	0
Total	**54**	**48**	**24**	**34**	**17**	**16**	**6**	**2**

Table 14. *Gulf of Mexico Pollution Sources Affecting Harvest-Limited Acreage, 1990* [a,b]

	Florida		Alabama		Mississippi		Louisiana		Texas	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Point Sources										
Sewage Treat Plants	394	*45*	86	*27*	27	*17*	265	*18*	201	*24*
Combined Sewers	7	*1*	0	*0*	0	*0*	204	*14*	0	*0*
Direct Discharge	2	*<1*	5	*2*	0	*0*	912	*60*	1	*<1*
Industry	205	*24*	0	*0*	39	*25*	218	*14*	60	*7*
Nonpoint Sources										
Septic Systems	697	*80*	0	*0*	15	*10*	580	*38*	471	*56*
Urban Runoff	466	*54*	0	*0*	32	*20*	643	*43*	135	*16*
Agricultural Runoff	4	*<1*	18	*6*	0	*0*	59	*4*	220	*26*
Wildlife	528	*61*	41	*13*	8	*5*	415	*28*	123	*15*
Boats	64	*7*	1	*<1*	94	*60*	225	*15*	123	*15*
Upstream Sources										
Sewage Treat Plants	131	*15*	2	*1*	3	*2*	1,038	*69*	0	*0*
Combined Sewer	7	*<1*	3	*<1*	0	*0*	13	*<1*	114	*3*
Urban Runoff	7	*<1*	211	*67*	3	*2*	562	*37*	10	*1*
Agricultural Runoff	0	*0*	211	*67*	0	*0*	3	*<1*	221	*26*
Wildlife	141	*16*	0	*0*	0	*0*	3	*<1*	66	*8*

a. Acres are times 1,000; % is percent of all harvest-limited acreage in state.

b. Since the same percentage of a shellfish area can be affected by more than one source, the percentages shown above cannot be added. They will not sum to 100.

approved to approved made by both Mississippi and Louisiana in Mississippi Sound. Mississippi completed sanitary surveys which enabled the State to open 124,000 acres, and Louisiana increased sampling efforts in the estuary, allowing the reclassification of 71,000 acres. Significant declines in approved waters occurred in Choctawhatchee Bay (53,000 acres), Pensacola Bay (43,000 acres), Mississippi Delta Region (7,000 acres), Brazos River (4,000 acres), Matagorda Bay (32,000 acres), San Antonio Bay (69,000 acres), and Upper Laguna Madre (226,000 acres).

Most of the region's classification changes were a result of management decisions based on increased sanitary survey and sampling activities. This expansion allowed Florida and Texas to increase their conditionally approved waters by 245,000 acres. Although Mississippi and Louisiana increased approved shellfish-growing waters, administrative limitations resulted in a 240,000 acre decrease in

conditionally approved waters in these states.

Pollution Sources Affecting Shellfish-Growing Waters. Pollution sources affecting the region's shellfish-growing waters reflect urbanization and industrialization around port cities, and the suburban and rural land uses which characterize about 95 percent of the region's estuarine drainage areas (NOAA, 1990). Nonpoint and upstream sources of pollution affect more harvest-limited shellfish-growing waters in the Gulf of Mexico than in any other region. Table 14 shows major categories of pollution sources affecting harvest-limited waters in the region. Data on pollution sources aggregated by estuary are given in Appendix D.

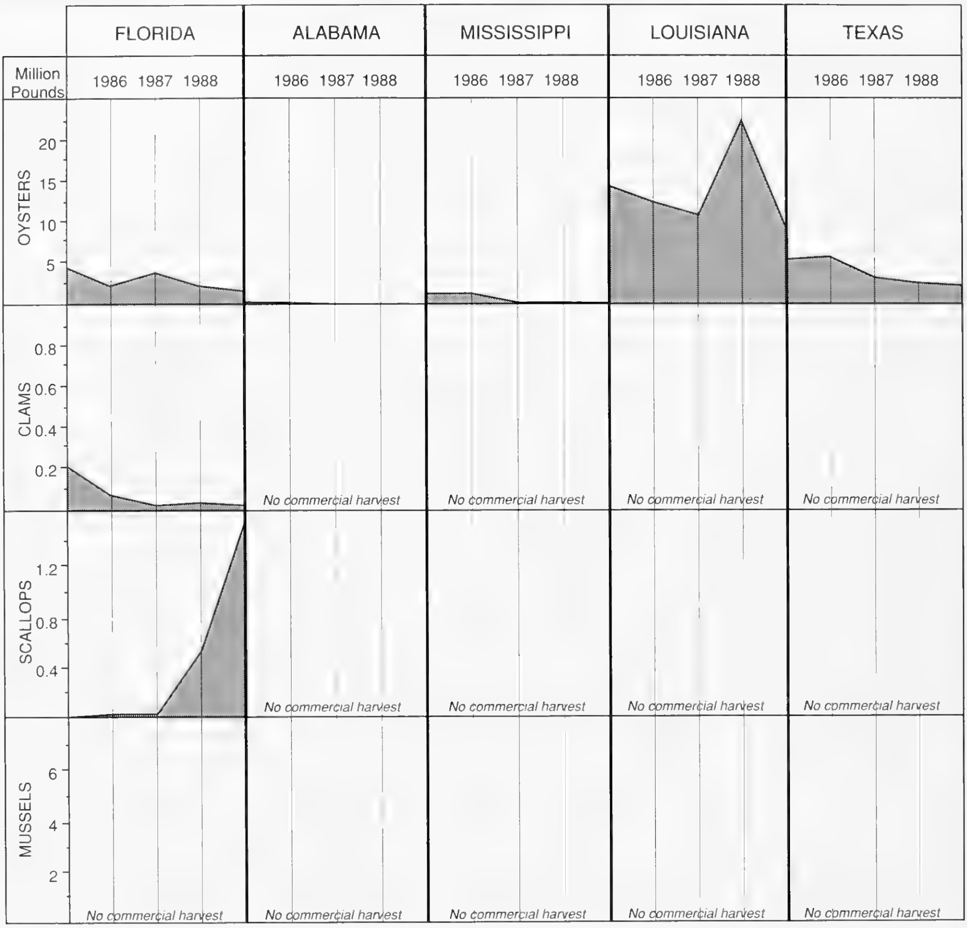
Among nonpoint sources, *septic systems* affect the most (48 percent) harvest-limited shellfish-growing waters. This is indicative of the many small communities in the region. Direct *urban runoff* affects 35 percent of the harvest-limited shellfish-growing waters and *upstream urban runoff* affects 22 percent, attributable to urbanization, high freshwater inflow, and low tidal influence. In addition, *wildlife* affects 30 percent of harvest-limited waters. NOAA estimates that over 80 percent of fecal coliform loads in the Gulf of Mexico are from nonpoint sources (Office of Technology Assessment, 1987).

Although nonpoint pollution affects the most harvest-limited waters, estuarine drainage areas in the Gulf of Mexico contain the greatest number of point sources among the regions, over 3,700, or 41 percent of the Nation's total. Point sources of pollution affect only about 14 percent of harvest-limited waters regionwide. Over half of the point sources are *industrial facilities*, many associated with the petrochemical industry and thus are concentrated around port cities. Galveston Bay, for example, contains 747 industrial point sources, the largest concentration in any estuary nationwide. Galveston Bay also contains 566 sewage treatment plants, 45 percent of the regional total.

Sewage treatment plants affect 27 percent of the region's harvest-limited waters, but are a major factor only in the most developed estuaries (about a third), such as Tampa Bay, Mobile Bay, Mississippi Sound, the Mississippi Delta Region, and Galveston Bay. *Direct discharges* are a major pollution factor, affecting 25 percent of harvest-limited waters. These are located primarily in sparsely populated areas of Louisiana, where small camps accommodate hunting and fishing activities.

Although most of the region's estuaries are rural, only eight percent of the harvest-limited shellfish-growing waters were affected by *agricultural runoff.* The amount of harvest-limited shellfish-growing waters affected by agricultural runoff is not expected to change greatly over the next five years, although *urban, industrial* and *recreational* sources of pollution are expected to increase. Between 1970 and 1990 the region's coastal population increased by 30 percent, and is

Figure 10. *Gulf of Mexico Commercial Shellfish Landings for Selected Species, 1985-1989*



expected to increase another 26 percent in the next 20 years (NOAA, 1990). Associated development will place further stresses on the quality and quantity of shellfish-growing waters in the Gulf.

Landings

Despite a 50 percent decline in oyster landings since 1985, the Gulf of Mexico has consistently led the Nation in oyster harvesting. By the end of 1990 further declines made the Gulf the Nation's second largest oyster-producing region, following the Pacific. However, during this period clam and mussel harvest has been the lowest among the regions. The exception is Florida where calico scallop landings have increased. Figure 10 shows landings in millions of pounds of

meats for the principal harvested species for the five states in the region.

Landings by State. *Florida's* oyster landings decreased from over four million pounds in 1985 to less than 1.5 million pounds in 1989. Clam landings also decreased from 215,000 pounds in 1985 to 18,000 pounds in 1989. In contrast to the State's east coast, where scallop landings declined, Gulf Coast landings increased from 5,000 pounds in 1986 to over 1.5 million pounds in 1989. Declines have been attributed to over-harvesting and increases in harvest-limited waters affected by pollution sources associated with coastal development. From Charlotte Harbor south, estuarine waters are used primarily for recreational harvest, and many of these waters were placed in the NSNP classification. In Pensacola Bay, Dermo infected and destroyed the oyster population as a result of higher drought-related salinities.

The oyster harvest in *Alabama* dropped from 1.3 million pounds in 1985 to 10,000 pounds in 1989. Although a significant spat set was reported in 1989, most of Mobile Bay remains closed for conservation purposes and as a result of local and upstream pollution. However, the main reason for large declines is Dermo, which returns to the Bay between hurricanes or major storm years when salinities increase. There also are indications that pollution and hypoxia may reduce the oyster's resistance to such diseases (Anderson, 1988). Consequently, natural harvesting on public reefs gradually is giving way to aquaculture, relaying, and private leases.

In *Mississippi*, oyster landings decreased from over one million pounds in 1985 to 100,000 pounds in 1989. Weather cycles have had effects similar to those in Alabama, resulting in periods of high salinity and Dermo. Oyster reefs in some waters, such as Biloxi Bay, have survived these cyclical events. However, many of these waters are closed due to coliform contamination from shoreline activities. Only a small part of Biloxi Bay's productive reefs are now classified as restricted and are available only for the relay of oysters.

Louisiana was the major oyster-producing state in the U.S. during the period. Over 14 million pounds of oysters were harvested in 1985, and the harvest increased to 22 million pounds in 1988. However, in 1989 oyster landings in Louisiana decreased to just over 8.7 million pounds. Declines in landings are attributed to disease, habitat loss and declines in approved waters. Approved waters often are located in areas of high salinity where diseases such as Dermo and predators such as the oyster drill cause high mortality. The most productive reefs are in conditionally approved waters where pollution brought in by heavy rains and high river stages closes waters to harvesting for extended periods. Much of the harvest involves transplanting seed oysters from restricted public seed waters to approved private growing waters, where they

complete the growth cycle. The process is labor-intensive, and mortality is almost 50 percent.

Oyster landings in *Texas* decreased from 5.1 million pounds in 1985 to two million pounds in 1989, harvested from 1.2 million acres of approved and conditionally approved shellfish-growing waters. In most cases, Texas classifications are influenced by rainfall and upstream pollution. The oyster harvest has been affected greatly by salinity extremes resulting from drought, hurricanes, storms and upstream rainfall events. The hypersaline conditions that dominated most of the waters between 1985 and 1990 led to widespread Dermo infections. Galveston Bay suffered additional declines from heavy rains in 1989, followed by an oil spill adjacent to Redfish Bar, the most productive reef in the State. However, a good setting of spat now has been observed in many parts of the Bay. State agencies are working on a plan to alter upstream dam releases to help stabilize salinities in eastern Texas estuaries. Matagorda and San Antonio bays, which had less salinity extremes during the period, had minor harvest increases. In 1986, a red tide infestation curtailed harvest and reduced some stock. The State has since initiated a biotoxin monitoring plan.

While declining in number, classic oyster-dredging boats in the Gulf waters of Louisiana still harvest half of the Nation's oysters.

Courtesy of Dorothy Leonard, NOAA

Figure 11. *Classified Shellfish-Growing Waters, 1990*

In the Pacific region, 428,000 acres of estuarine waters were classified for shellfish harvest in 1990 (Figure 11). Thirty-three percent were approved and 67 percent harvest-limited. This region has the least classified estuarine waters and the smallest percentage of approved waters in the Nation. In addition, 216,000 acres were classified in Alaska and Hawaii, of which 198,000 were approved.

Estuarine Shellfish-Growing Waters. The Pacific region extends from California's Tijuana estuary to Puget Sound. Estuaries in the region are small compared to others nationwide. Over half have water surface areas of less than five square miles. Except for San Francisco Bay, Columbia River, and Puget Sound, most of these small estuaries also are shallow, and their circulation is dominated by riverine influences (NOAA, 1990). Consequently, habitat for intertidal molluscan shellfish is limited, and most of the harvest is from aquaculture. The Pacific region has the second lowest amount of total coastal wetlands in the Nation (NOAA, 1991b). These smaller estuaries are also highly sensitive to the effects of pollution (NOAA, 1990). For example, declines in water quality in Southern California resulting from urbanization have restricted most harvest in the State to the classified shellfishing areas north of San Francisco Bay. Appendix C identifies the estuaries in the region and summarizes the status of shellfish-growing waters in each.

Classified Shellfish-Growing Waters, 1985-1990. Approved estuarine shellfish-growing waters (excluding Alaska and Hawaii) declined from 42 to 33 percent of classified waters between 1985 and 1990, a downgrade of almost 20,000 acres. Of the total 428,000 classified acres in the region, about 275,000 (67 percent) acres are now classified as harvest-limited. An additional 35,000 acres of shellfish-growing waters were classified (all as restricted) during the period.

Declines in approved shellfish-growing waters occurred in Washington and Oregon. Although California increased its approved waters by 1,000 acres, it also increased prohibited waters by 20,000 acres. This occurred primarily in response to an increase in applications for aquaculture leases.

Table 15. *Distribution of Pacific Classified Estuarine Waters, 1985 and 1990*

	Percent Classified							
	Approved		Prohibited		Conditional		Restricted	
State	85	90	85	90	85	90	85	90
CA	2	2	86	88	11	9	1	1
OR	35	22	36	35	30	42	0	2
WA	61	50	20	22	19	18	0	11
AK	nd	100	nd	0	nd	0	nd	0
HI	nd	0	nd	100	nd	0	nd	0
Total	**42**	**53**	**40**	**31**	**18**	**11**	**1**	**5**

Abreviations: nd, no data

Table 16. *Pacific Pollution Sources Affecting Harvest-Limited Acreage, 1990* [a,b]

	California		Oregon		Washington		Alaska		Hawaii	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Point Sources										
Sewage Treat Plants	16	*13*	5	*18*	53	*40*	0	*0*	1	*6*
Combined Sewers	0	*0*	0	*0*	0	*0*	0	*0*	0	*0*
Direct Discharge	0	*0*	6	*21*	0	*0*	0	*0*	0	*0*
Industry	86	*68*	0	*0*	37	*28*	0	*0*	6	*33*
Nonpoint Sources										
Septic Systems	11	*9*	9	*32*	37	*28*	0	*0*	0	*0*
Urban Runoff	26	*20*	12	*43*	54	*41*	0	*0*	18	*100*
Agricultural Runoff	18	*14*	8	*29*	15	*11*	0	*0*	0	*0*
Wildlife	18	*14*	0	*0*	4	*3*	0	*0*	17	*94*
Boats	25	*20*	6	*21*	10	*8*	0	*0*	6	*33*
Upstream Sources										
Sewage Treat Plants	0	*0*	2	*7*	43	*33*	0	*0*	0	*0*
Combined Sewer	0	*0*	0	*0*	0	*0*	0	*0*	0	*0*
Urban Runoff	0	*0*	0	*0*	43	*33*	0	*0*	0	*0*
Agricultural Runoff	0	*0*	0	*0*	0	*0*	0	*0*	0	*0*
Wildlife	0	*0*	0	*0*	0	*0*	0	*0*	0	*0*

a. Acres are times 1,000; % is percent of all harvest-limited acreage in state.

b. Since the same percentage of a shellfish area can be affected by more than one source, the percentages shown above cannot be added. They will not sum to 100.

Declines occurred in five of the 20 estuaries with classified shellfish-growing waters. An increase in approved waters occurred in Drakes Estero as additional acres were placed into production. Particularly significant are the declines in approved waters in Yaquina Bay and Skagit Bay, where 5,400 acres were reclassified as restricted. Of the Region's three largest estuaries (San Francisco Bay, Columbia River, and Puget Sound) only Puget Sound had approved shellfish-growing waters. These continued to decline. For example, urban runoff and shoreline development caused downgrades in Oakland Bay (820 acres) and Lynch Cove (630 acres). Willapa Bay, the most productive shellfishing area in the region, also experienced declines as a result of increasing shoreline development. Over 2,000 acres have been reclassified from approved to restricted.

As in other regions, most of the changes in classification were a result of management decisions based on increased sanitary survey and sampling activities.

Classified Shellfish-Growing Waters in Alaska and Hawaii, 1990. There were 36 areas classified as approved in Alaska, totaling nearly 198,000 acres. Another 7,000 acres have production potential or already contain aquaculture operations. There are no harvest-limited waters. A growing industry based on aquaculture is producing oysters, mussels, and clams, a portion of which are shipped within Alaska. The wild harvesting of razor clams has also increased.

In Hawaii, interest in oyster and clam culture has resulted in the classification of one acre as approved and 17 acres as conditionally approved. Over 18,000 acres remain prohibited as a result of pollution from urban, industrial, and boating sources.

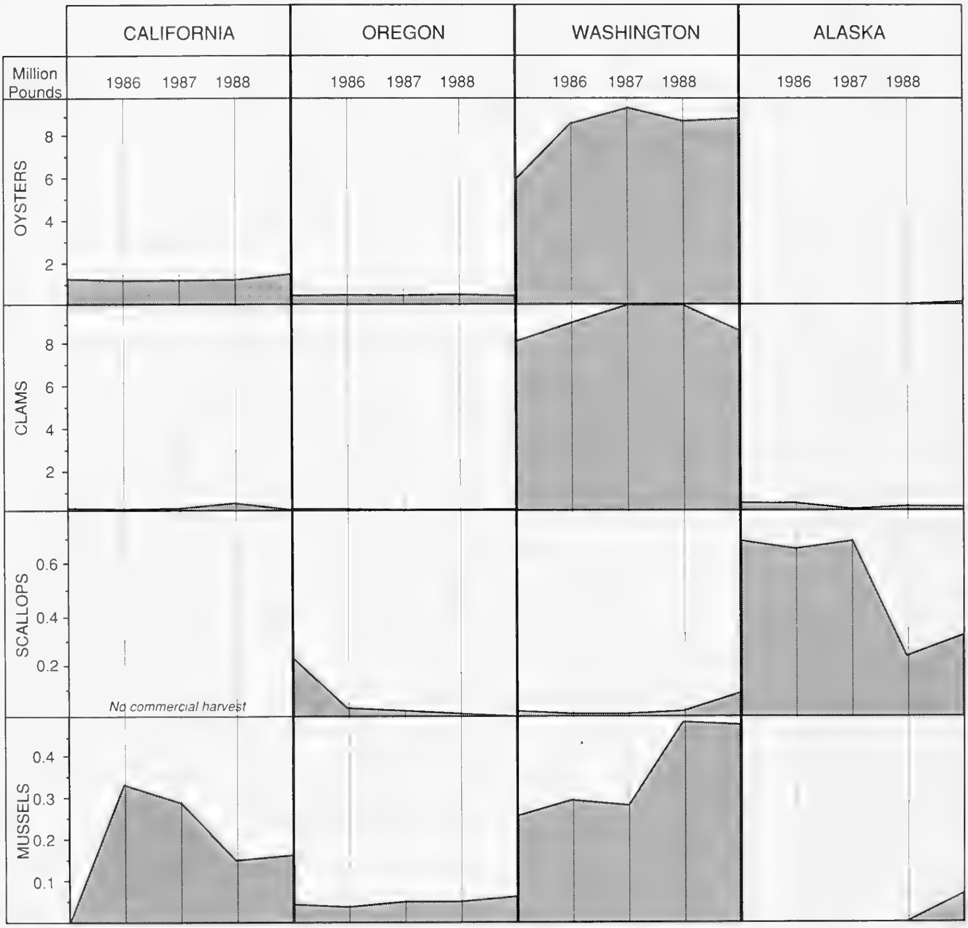
Pollution Sources Affecting Shellfish-Growing Waters. Many of the pollution sources affecting Pacific shellfish-growing waters reflect expanding urbanization in the region. The region's population is expected to double between 1960 and 2010 to nearly 46 million, 77 percent of which will reside in coastal counties (Culliton et al., 1990). Table 16 shows the major categories of pollution sources affecting the harvest-limited waters in the region. Data on pollution sources aggregated by estuary are provided in Appendix D.

Many urban centers in the Pacific region use *ocean outfalls.* Consequently, there are fewer than 1,000 point sources of pollution in estuarine drainage areas of the Pacific region, the second fewest among regions (NOAA, 1990). However, the Pacific region has the Nation's highest percentage (42 percent) of harvest-limited shellfish-growing waters affected by *industry.* Three-quarters of the industrial dischargers are located in Puget Sound, Columbia River, San Francisco Bay, and San Pedro Bay. Three of the largest point source dischargers are pulp and paper mills located along Columbia River. Of these large estuaries, only Puget Sound currently has commercial harvest.

Sewage treatment plants affect 25 percent of the harvest-limited shellfish-growing waters and are concentrated in the San Pedro, Santa Monica, and San Francisco bays, Columbia River, and Puget Sound estuarine drainage areas. An additional 16 percent are affected by sewage treatment plants located upstream. Many sewage treatment plants in Southern California have contributed to the removal of southern shellfish-growing waters from classification. One of the few harvests south of Drakes Estero in 1990 was from oil platform aquaculture projects in the Santa Barbara Channel.

Urban runoff and *faulty septic systems* are also significant, affecting 36 and 19 percent of harvest-limited waters respectively. *Agricultural runoff* affects 13 percent of these waters and is particularly significant in Tillamook Bay because of extensive agricultural lands used primarily for dairy operations. Over 23,000 cows contribute more than three million tons of manure annually.

Figure 12. *Pacific Commercial Shellfish Landings for Selected Species, 1985-1989*



Landings

Overall commercial landings of molluscan shellfish in the region are the lowest in the Nation. However, Pacific oyster culture has grown steadily, followed by increased aquaculture in clams, mussels, and other species. The oyster culture began just after the turn of the century, and expanded to almost 11 million pounds by 1990. By the end of 1990, the region's oyster landings were the highest in the Nation. Recreational harvest of many natural stocks is still significant (NOAA, 1991a). Figure 12 shows landings in millions of pounds of meats for the principal harvested species by state in the region.

Landings by Major Bays. *Morro Bay* was one of the State's leading producers of Pacific oysters until the 1970s. However, increasing sewage contamination reduced landings to 179,000 pounds in 1979, and to 18,000 pounds in 1984. The harvest declined further to 12,000 pounds in 1985, and finally to zero in 1990. *Drakes Estero* is now the southernmost major source of oysters in the region, producing over 700,000 pounds annually. *Humboldt Bay* oyster landings dropped from 1.5 million pounds in 1962 to about 500,000 pounds in 1988. The primary reason was increasing restrictions imposed following rainfall, when fecal coliform levels exceeded standards. However, the State and local industry developed an innovative cooperative management program which will reduce closures.

Tillamook Bay oyster production declined dramatically from 588,000 pounds in 1968 to 300,000 pounds in 1985, where it has stabilized. The primary reason for this decline was runoff from agricultural activities, especially dairy farm operations. Recently, clean-up efforts by local farmers and municipalities have improved the quality.

An annual oyster harvest of about five million pounds from *Willapa Bay* represents about half of Washington's production. This harvest is almost 20 percent of the Nation's oyster production, making this estuary the most productive per acre of surface water in the Nation. At the same time, shellfish-growing water closures in Willapa Bay in 1990 resulted from increases in human activities, including clear-cutting of timber. As a result, many local conservation initiatives have been undertaken.

Puget Sound leads the region's landings with over 13 million pounds annually. Subtidal scallop and mussel harvests increased, while intertidal oyster and clam harvests remained steady. To maintain this production, Washington committed significant resources to monitoring the pollution effects caused by rapid population growth as well as the increasing problem of nonpoint pollution in the area. Consequently, the amount of management funds per acre is higher for Puget Sound than for any other estuary in the Nation.

Landings by State. The production of oysters in *California* increased from 1.2 million pounds in 1985 to 1.5 million pounds in 1989, primarily from aquaculture in Drakes Estero, and Humboldt and Tomales bays. At the turn of the century, San Francisco Bay led the State in oyster production. However, exploitation, pollution, high mortality rates, and poor reproduction ended commercial harvest by 1939.

Landings of clams (40,000 to 440,000 pounds) and mussels (150,000 to 335,000 pounds) are highly variable across the State. One of the most successful mussel culture operations takes place on oil platforms in Santa Barbara Channel. However, most harvest, other than oysters, is by recreational fishermen. The responsibility for protection of recreational shellfish-growing waters and fishermen is left to local governments.

Oregon oyster landings remained steady at about 400,000 pounds between 1985 and 1989. Similarly, annual mussel landings remained at 50,000 pounds. Clam landings declined from 99,000 to 64,000 pounds. Marine biotoxic plankton blooms reduced the scallop harvest from 205,000 pounds to zero.

Washington is the largest producer of shellfish in the region, harvesting over 18 million pounds in 1989. Harvests of oysters, clams, scallops, and mussels have all increased. Four species of scallops were harvested, more than in any other state in the Nation. Scallop harvest increased from 51,000 pounds in 1985 to 307,000 pounds in 1989.

Alaska was once a major producer of razor clams. After reaching a peak of 16 million pounds in 1916, over-harvesting, paralytic shellfish poisoning, and market conditions eliminated commercial landings by 1961. After receiving approval for its Shellfish Sanitation Program in 1975, Alaska began to rebuild its shellfishing industry. Species currently harvested include razor clams, littleneck clams, and geoducks. However, overall landings declined from 1.1 million pounds in 1985 to about 700,000 pounds in 1989. An aquaculture-based oyster industry had its first landings (106,000 pounds) in 1989. Local growers are beginning to explore the aquaculture potential in Alaska's high-quality classified shellfish-growing waters.

Good water quality allows Pacific aquaculturists to produce nearly half of the Nation's oysters.

Courtesy of Dorothy Leonard, NOAA

Concluding Comments

This report has described declines in estuarine water quality, decreases in the acreage of approved molluscan shellfish waters, and continuing declines in the Nation's shellfish harvests. Although declines in any given year are not especially dramatic, an almost inexorable trend that threatens to destroy the harvest of wild or natural shellfish continues throughout the Nation's coastal areas.

The six percent decline in approved shellfish-growing waters from 1985 to 1990 (736,000 acres) was accompanied by a 1.2 million acre increase in prohibited waters. These changes were primarily the result of expanding coastal development, represented by increases in harvest-limited acreage (1.2 million acres) affected by urban runoff, faulty septic systems, marina development, and buffer zones around sewage treatment plants. The rate of decline in approved acreage is highest in the most productive estuaries such as Chesapeake Bay, the Mississippi Delta Region estuaries, and Puget Sound. The coastal drainage areas affecting these estuaries already receive some of the heaviest pollution loads in the U.S., a condition that is not likely to change as development continues. NOAA previously reported that between 1960 and 2010, the coastal population will grow from 80 million to more than 127 million, an increase of almost 60 percent (Culliton et al., 1990).

According to molluscan shellfish growers, "The real battle is to mitigate the impacts of humans. No clean water, no oysters." (Fitzgerald, 1989).

A notable example of the impact of coastal development on shellfish-growing waters is the increase in harvest-limited waters (about 50 percent) affected by pollution associated with recreational boating. Increases in recreational boating in many coastal areas have resulted in a proliferation of marinas, many of which do not have facilities to collect or process sewage. Many marinas are located in or near productive shellfish-growing areas, as are the housing and other facilities related to such development. Consequently, in 1990 pollution from boating and marinas affected more than 25 percent of the harvest-limited shellfish-growing waters in half of the shellfish-producing states.

An Increasing Role for Aquaculture. Declines in approved shellfish-growing waters have been paralleled by declines in the harvests of wild or natural stocks of molluscan shellfish. A continued decline in the water quality of productive estuaries in combination with the problems of over-harvesting and disease, may eventually eliminate the natural harvest of shellfish.

Successful aquaculture operations in estuaries such as Willapa Bay have shown that sustained production can be achieved. However, aquaculture requires access to both high quality water and a nearby land base. In addition, successful aquaculture

requires exclusive use of parcels of land and water, often competing with other uses such as swimming, boating, fishing, and navigation. Although well-established in a few estuaries, aquaculture is not yet encouraged by many existing laws and regulations governing private access to public lands and approved shellfish-growing waters (South Carolina Sea Grant Consortium, 1989). Without increases in aquaculture it is likely that harvests of estuarine molluscan shellfish will continue to decline, as they did in the 1990 statistical year according to the most recent data from the National Marine Fisheries Service.

> Shellfish program management resources were reduced in half of the Nation's shellfish-producing states between 1985 and 1990.

Beyond 1990. Although reporting on the classifications of shellfish-growing waters began with the 1966 Register, data have only been collected and analyzed on pollution sources, landings, and state shellfish programs since 1985. Thus, the inferences on relationships between classification, pollution sources, and harvest are based most heavily on a five-year period between 1985 and 1990. Data collection for the 1995 Register will begin in late 1994. If trends reported in the 1990 Register continue, the 1995 Register will reveal further declines in approved and conditionally approved shellfish-growing waters, and in harvests of wild stocks. Continued declines in the resources necessary for states to monitor, classify, and manage waters may reduce further the Nation's ability to sustain wild and natural stocks of molluscan shellfish by 1995.

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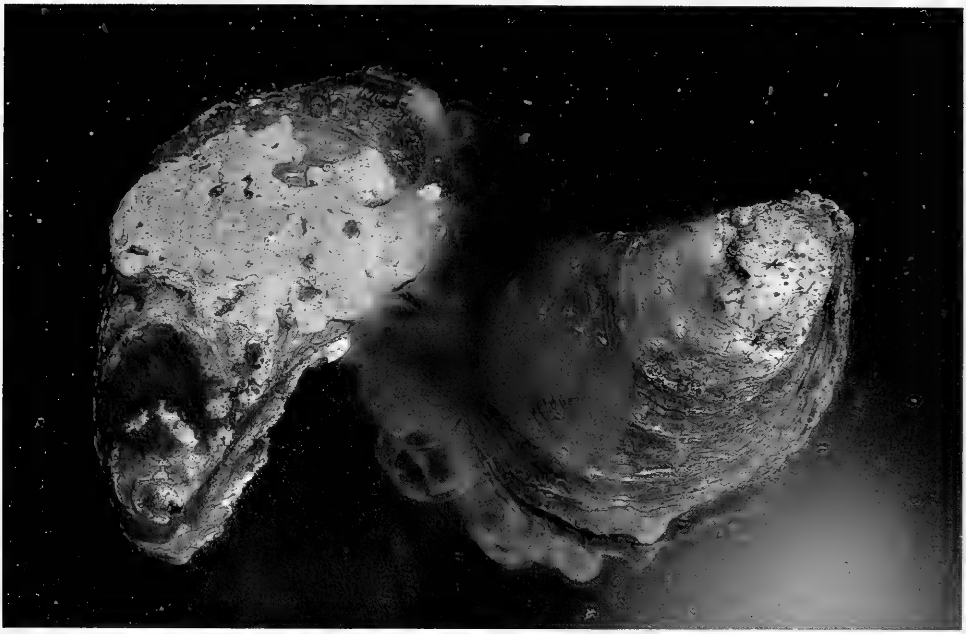
The fertilization process of the American oyster (Crassostrea virginica).



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Appendices

National Estuarine Inventory

The goal of the National Estuarine Inventory (NEI) is to develop a comprehensive framework for evaluating the health and status of the Nation's estuaries, and to bring estuaries into focus as a national resource base. The principal spatial unit for which all data are organized is the estuarine drainage area, or EDA, defined as *that land and water component of an entire watershed that most directly affects an estuary* (NOAA, 1985). EDA boundaries coincide, where possible, with U.S. Geological Survey (USGS) Hydrologic Cataloging Units within which the head of tide of an estuary falls. These data are being used to make comparisons, rankings, statistical correlations, and other analyses related to resource use, environmental quality, and economic values among estuaries.

The cornerstone of the NEI is the *National Estuarine Inventory Data Atlas, Volume 1: Physical and Hydrologic Characteristics* (NOAA, 1985). This atlas identifies 92 of the most important estuaries of the conterminous U.S. and presents information through maps and tables. These estuaries represent approximately 90 percent of the estuarine water surface area and 90 percent of the freshwater inflow to marine waters of the Atlantic, Pacific, and Gulf of Mexico coasts.

Volume 2, Land Use Characteristics, presents area estimates for seven categories and 24 subcategories of land use, as well as population estimates for 1970 and 1980 (NOAA, 1987). Land use estimates come from the USGS Land Use and Land Cover Program and are compiled for three spatial units: (1) estuarine drainage area; (2) USGS hydrologic cataloging unit; and (3) counties intersecting EDAs. Population estimates are compiled for EDAs only.

Volume 3, Coastal Wetlands --New England Region (NOAA, 1989) presents wetlands acreage estimates for 12 wetland types in 16 EDAs and 42 counties from Maine to Connecticut. The data are a subset of those presented in this report. Computer-generated color maps of selected EDAs are also presented.

Volume 4, Public Recreation Facilities in Coastal Areas (NOAA, 1988), presents data for Federal, State, and local recreation facilities in 327 counties bordering tidally influenced water and 25 estuary groups. A total of 1,589 public agencies that owned and/or managed outdoor recreation sites and facilities in coastal areas provided data for the inventory.

Other NOAA projects contributing data and information to the NEI include the Estuarine Living Marine Resources program, the quality of shellfish-growing waters and related projects, the National Coastal Pollutant Discharge Inventory, and the Outdoor Resource Economics program. The NEI represents the most consistent and comprehensive set of data describing the Nation's estuarine resource base.

Additional Activities

A number of additional NEI activities are now under way or planned. Based on the review of Volume 1 of the NEI by estuarine scientists and State and Federal resource managers, several areas have been identified for improvement in future editions.

New Estuaries Added. New estuaries of local or regional importance have been added. Eight estuaries in Oregon have been added due to their biological importance to coastal fisheries. Five new EDAs have been delineated to represent the original Mississippi Delta Region because of a need for increased resolution. A limited number of additions to other portions of the Pacific, Atlantic, and Gulf of Mexico regions have also been made.

A new NOAA report, *Estuaries of the United States, Vital Statistics of a National Resource Base*, updates the NEI. The report provides information on an expanded number of EDAs (102), including physical and hydrologic features, natural resources, economic activities, and pollution susceptibility. These EDAs and the counties falling within their boundaries are the units for which all NEI data are now collected. The wetlands data presented in Appendix D are organized according to this framework.

Improved Salinity Resolution. Another recommendation was to improve the resolution of the salinity regimes mapped for each estuary. Based on a study of Mobile Bay to determine if bottom and surface salinities could be mapped in zones of five parts per thousand increments for periods of high and low flow, an effort to compile data for EDAs along the Gulf Coast is now nearing completion. This detailed depiction will characterize the effects of freshwater inflow, tides, and wind on salinity patterns more completely than the three average annual salinity zones described in Volume I of the NEI.

Other Projects. A project focusing on the agricultural use of 28 selected pesticides on 71 crops in 78 EDAs was completed in 1989. Future NEI volumes on additional topics are also planned. For example, a project to characterize the distribution and abundance of fishes and invertebrates in estuaries began in 1985. To date, information has been compiled on 103 species in 83 estuaries on the Pacific, Gulf of Mexico, and South Atlantic coasts, and information is currently being compiled for 62 species in 34 North Atlantic estuaries.

Classification Trends 1985-1990 (Acres x 1000)

Region/State	Approved		Conditional		Restricted		Prohibited		Total Classified		Non-shellfish/ Non-productive	
	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990
Maine	929	1,583	11	7	10	1	83	195	1,034	1,786	0	0
Estuarine[a]	*929*	*699*	*11*	*7*	*10*	*1*	*83*	*195*	*1,034*	*902*	*0*	*0*
Offshore[b]	*0*	*884*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*884*	*0*	*0*
New Hampshire	4	4	0	0	1	7	7	2	13	13	<1	2
Massachusetts	66	426	0	2	5	3	23	180	95	566	554	55
Estuarine	*66*	*77*	*<1*	*2*	*5*	*3*	*23*	*135*	*95*	*217*	*177*	*55*
Offshore	*0*	*349*	*0*	*0*	*0*	*0*	*0*	*45*	*0*	*349*	*377*	*0*
North Atlantic Total	**1,000**	**2,014**	**10**	**9**	**17**	**11**	**113**	**377**	**1,141**	**2,410**	**554**	**57**
Estuarine	***1,000***	***781***	***10***	***9***	***17***	***11***	***113***	***332***	***1,141***	***1,132***	***177***	***57***
Offshore	***0***	***1,233***	***0***	***0***	***0***	***0***	***0***	***45***	***0***	***1,278***	***377***	***0***
Massachusetts	198	102	1	2	0	0	17	84	217	189	2	0
Rhode Island	96	94	20	21	<1	4	19	16	135	135	0	1
Connecticut	310	243	6	6	64	41	45	67	425	357	0	68
New York	823	808	71	84	0	<1	202	185	1,096	1,077	<1	18
New Jersey	232	446	20	21	21	22	171	180	444	668	20	0
Estuarine	*232*	*240*	*20*	*21*	*21*	*22*	*119*	*121*	*392*	*403*	*4*	*0*
Offshore	*0*	*206*	*0*	*0*	*0*	*0*	*52*	*59*	*52*	*265*	*16*	*0*
Delaware	209	170	3	3	<1	0	19	58	231	231	43	43
Maryland	1,313	1,253	0	63	7	16	55	43	1,375	1,375	174	172
Virginia	1,300	1,311	31	16	126	133	119	115	1,575	1,575	47	47
Middle Atlantic Total	**4,480**	**4,427**	**152**	**217**	**218**	**217**	**648**	**747**	**5,498**	**5,608**	**286**	**348**
Estuarine	***4,480***	***4,221***	***152***	***217***	***218***	***217***	***596***	***688***	***5,446***	***5,343***	***270***	***348***
Offshore	***0***	***206***	***0***	***0***	***0***	***0***	***52***	***59***	***52***	***265***	***16***	***0***

a. Estuarine shellfish-growing waters extend through most of the transition zone between freshwater and seawater.
b. Offshore shellfish-growing waters extend seaward to the three-mile limit.

Classification Trends 1985-1990 (Acres x 1000) (cont.)

Region/State	Approved		Conditional		Restricted		Prohibited		Total Classified		Non-shellfish/ Non-productive	
	1985	**1990**	**1985**	**1990**	**1985**	**1990**	**1985**	**1990**	**1985**	**1990**	**1985**	**1990**
North Carolina	1,803	1,812	36	47	0	1	406	427	2,245	2,286	0	0
South Carolina	201	192	9	9	0	30	68	48	279	279	0	1
Georgia	51	48	0	0	14	5	102	115	168	168	10	10
Florida	40	40	37	63	<1	65	37	41	114	208	469	379
South Atlantic Total	**2,096**	**2,091**	**82**	**119**	**15**	**102**	**612**	**630**	**2,805**	**2,940**	**479**	**390**
Estuarine [a]	***2,096***	***2,091***	***82***	***119***	***15***	***102***	***612***	***630***	***2,805***	***2,940***	***479***	***390***
Offshore [b]	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***
Florida	238	157	332	444	0	46	278	351	847	998	784	702
Alabama	57	57	211	211	0	0	86	104	354	371	2	2
Mississippi	153	277	171	34	2	57	107	66	433	434	0	0
Louisiana	1,740	1,885	430	327	383	0	806	1,182	3,358	3,394	45	0
Texas	1,475	1,058	4	137	0	0	372	703	1,851	1,897	2	2
Gulf of Mexico Total	**3,662**	**3,434**	**1,147**	**1,153**	**385**	**103**	**1,649**	**2,405**	**6,843**	**7,095**	**833**	**706**
Estuarine	***3,662***	***3,434***	***1,147***	***1,153***	***385***	***103***	***1,649***	***2,405***	***6,843***	***7,095***	***833***	***706***
Offshore	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***

a. Estuarine shellfish-growing waters extend through most of the transition zone between freshwater and seawater.
b. Offshore shellfish-growing waters extend seaward to the three-mile limit.

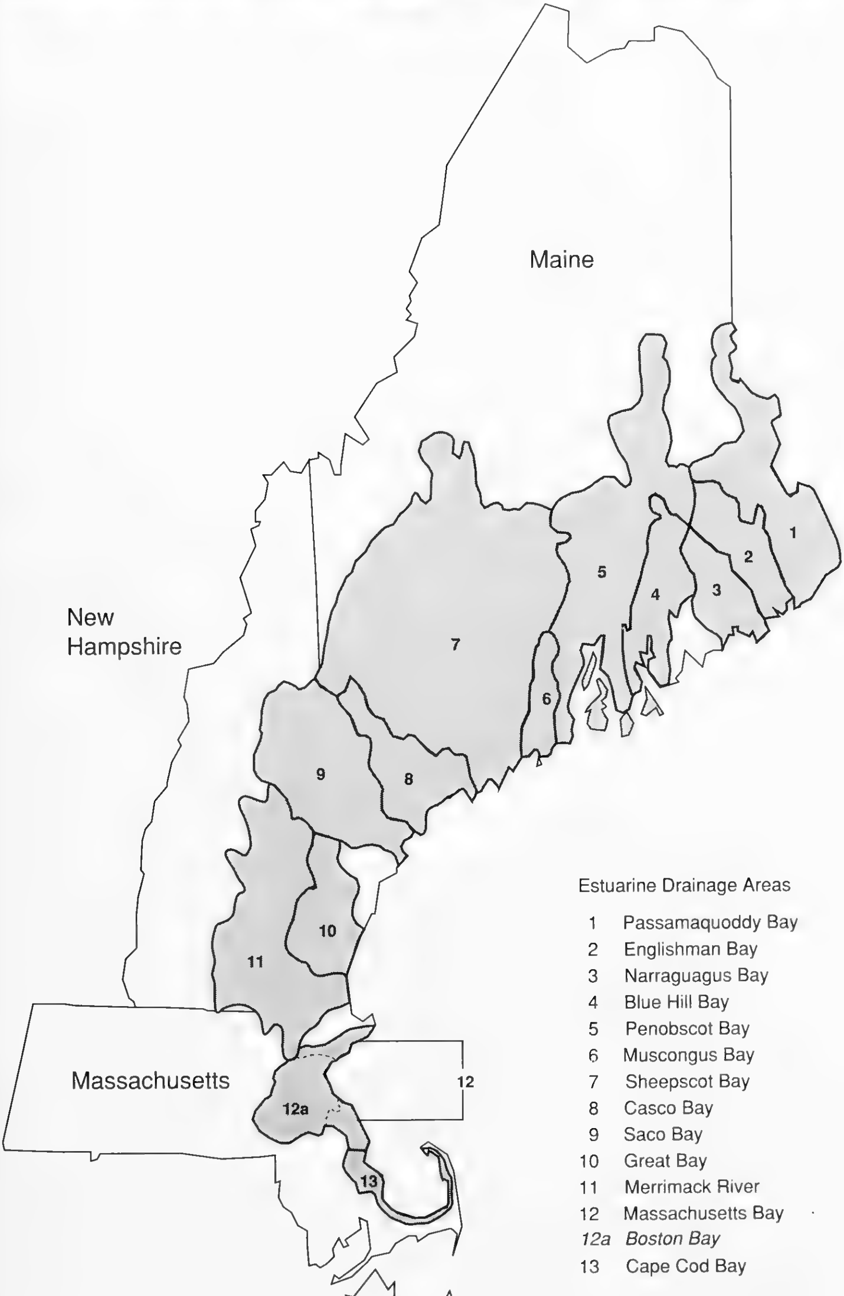
Classification Trends 1985-1990 (Acres x 1000) (cont.)

Region/State	Approved		Conditional		Restricted		Prohibited		Total Classified		Non-shellfish/ Non-productive	
	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990
California	2	2	12	12	2	1	94	115	110	130	451	605
Estuarine[a]	*2*	*2*	*12*	*12*	*2*	*1*	*94*	*114*	*110*	*129*	*450*	*604*
Offshore[b]	*<1*	*<1*	*0*	*0*	*0*	*0*	*0*	*<1*	*<1*	*1*	*1*	*1*
Oregon	14	8	12	15	0	1	14	12	39	36	44	49
Washington	148	130	46	46	0	29	48	57	243	262	1,794	1,788
Alaska	0	198	0	0	0	0	0	0	0	198	0	7
Hawaii	0	0	0	<1	0	0	157	18	0	18	0	0
Pacific Total	**164**	**338**	**70**	**73**	**2**	**31**	**157**	**202**	**392**	**644**	**2,289**	**2,450**
Estuarine	***164***	***338***	***70***	***73***	***2***	***31***	***157***	***201***	***392***	***643***	***2,288***	***2,449***
Offshore	***<1***	***<1***	***0***	***0***	***0***	***0***	***0***	***<1***	***<1***	***527***	***593***	***513***
U.S. Total	**11,401**	**12,303**	**1,462**	**1,571**	**636**	**462**	**3,179**	**4,361**	**16,678**	**18,697**	**4,447**	**3,956**
Estuarine	***11,401***	***10,863***	***1,462***	***1,571***	***636***	***462***	***3,127***	***4,257***	***16,626***	***17,153***	***4,053***	***3,955***
Offshore	***0***	***1,440***	***0***	***0***	***0***	***0***	***52***	***104***	***52***	***1,544***	***394***	***1***

a. Estuarine shellfish-growing waters extend through most of the transition zone between freshwater and seawater.

b. Offshore shellfish-growing waters extend seaward to the three-mile limit.

North Atlantic



Estuarine Drainage Areas

1 Passamaquoddy Bay
2 Englishman Bay
3 Narraguagus Bay
4 Blue Hill Bay
5 Penobscot Bay
6 Muscongus Bay
7 Sheepscot Bay
8 Casco Bay
9 Saco Bay
10 Great Bay
11 Merrimack River
12 Massachusetts Bay
12a Boston Bay
13 Cape Cod Bay

Note: Sub-estuaries are in italics.

North Atlantic (Acres x 1,000)

Estuary	Approved		Conditional		Restricted		Prohibited		Total		% Approved		% HL	
	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990
Passamaquoddy Bay	34	33	<1	–	–	–	6	7	40	40	85	83	15	17
Englishman Bay	64	–	<1	1	1	–	2	3	67	4	95	–	5	100
Narraguagas Bay	83	41	<1	–	–	–	1	1	85	42	98	97	2	3
Blue Hill Bay	71	48	–	–	–	–	3	<1	73	48	96	100	4	–
Penobscot Bay	345	215	3	4	3	–	27	60	379	280	91	77	9	23
Muscongus Bay	65	66	2	<1	1	–	2	7	69	74	94	90	6	10
Sheepscot Bay	37	68	2	–	2	–	23	26	64	94	57	72	43	28
Casco Bay	123	113	2	1	1	1	12	32	139	147	89	77	11	23
Saco Bay	21	15	–	<1	1	<1	2	8	24	24	88	62	12	38
Great Bay	4	4	–	–	2	7	10	4	15	14	25	28	75	72
Merrimack River	–	–	–	–	<1	–	2	2	2	2	–	–	100	100
Massachusetts Bay	4	23	–	–	<1	<1	12	92	15	115	23	20	77	80
Boston Bay	–	–	–	–	*4*	*2*	*5*	*27*	*9*	*30*	–	–	*100*	*100*
Cape Cod Bay	45	42	<1	<1	–	–	3	8	49	50	93	84	7	16
Other	105	113	1	2	2	1	3	53	111	169	95	67	5	33
North Atlantic Total	**1,000**	**781**	**10**	**9**	**17**	**11**	**113**	**332**	**1,141**	**1,132**	**88**	**69**	**12**	**31**
National Total	**11,401**	**10,863**	**1,462**	**1,571**	**636**	**462**	**3,127**	**4,257**	**16,626**	**17,153**	**69**	**63**	**31**	**37**

Abbreviations: HL, harvest-limited; –, no acreage.

Note: Not shown above are Non-shellfish/Non-productive classifications, which totaled 177,000 acres in 1985 and 56,000 acres in 1990. Sub-estuaries are in italics.

Middle Atlantic

Estuarine Drainage Areas

1	Buzzards Bay
2	Narragansett Bay
3	Gardiners Bay
4	Long Island Sound
4a	*Connecticut River*
5	Great South Bay
6	Hudson River/Raritan Bay
7	Barnegat Bay
8	New Jersey Inland Bays
9	Delaware Bay
10	Delaware Inland Bays
11	Chincoteague Bay
12	Chesapeake Bay
12a	*Patuxent River*
12b	*Potomac River*
12c	*Rappahannock River*
12d	*York River*
12e	*James River*
12f	*Chester River*
12g	*Choptank River*
12h	*Tangier/Pocomoke Sounds*

Note: Sub-estuaries are in italics.

Middle Atlantic (Acres x 1,000)

Estuary	Approved		Conditional		Restricted		Prohibited		Total		% Approved		% HL	
	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990
Buzzards Bay	127	64	<1	1	–	–	9	57	137	122	93	52	7	48
Narragansett Bay	96	94	20	21	<1	4	25	21	141	141	68	67	32	33
Gardiners Bay	124	124	<1	1	–	–	2	2	126	126	98	98	2	2
Long Island Sound	926	859	6	6	62	39	107	128	1,101	1,034	84	83	16	17
Connecticut River	*–*	*–*	*–*	*–*	*2*	*2*	*3*	*3*	*5*	*5*	*–*	*–*	*100*	*100*
Great South Bay	82	68	3	15	–	<1	37	37	122	121	68	57	32	43
Hudson River/Raritan Bay	–	–	68	68	20	20	135	114	223	202	–	–	100	100
Barnegat Bay	21	21	6	6	–	–	10	10	37	37	56	56	44	44
New Jersey Inland Bays	39	46	7	8	<1	<1	10	13	57	67	69	69	31	31
Delaware Bay	351	311	6	6	<1	1	65	104	423	423	83	74	17	26
Delaware Inland Bays	12	12	3	3	–	–	4	3	19	19	64	65	36	35
Chincoteague Bay	104	99	–	–	2	2	<1	<1	106	101	98	98	2	2
Chesapeake Bay	1,708	1,701	12	43	23	32	42	32	1,785	1,808	96	94	4	6
Patuxent River	*–*	*–*	*–*	*–*	*–*	*–*	*–*	*–*	*–*	*–*	*–*	*–*	*–*	*–*
Potomac River	*254*	*244*	*1*	*14*	*4*	*4*	*3*	*2*	*263*	*265*	*97*	*92*	*3*	*8*
Rappahannock River	*64*	*70*	*<1*	*<1*	*13*	*13*	*–*	*–*	*77*	*83*	*84*	*84*	*16*	*16*

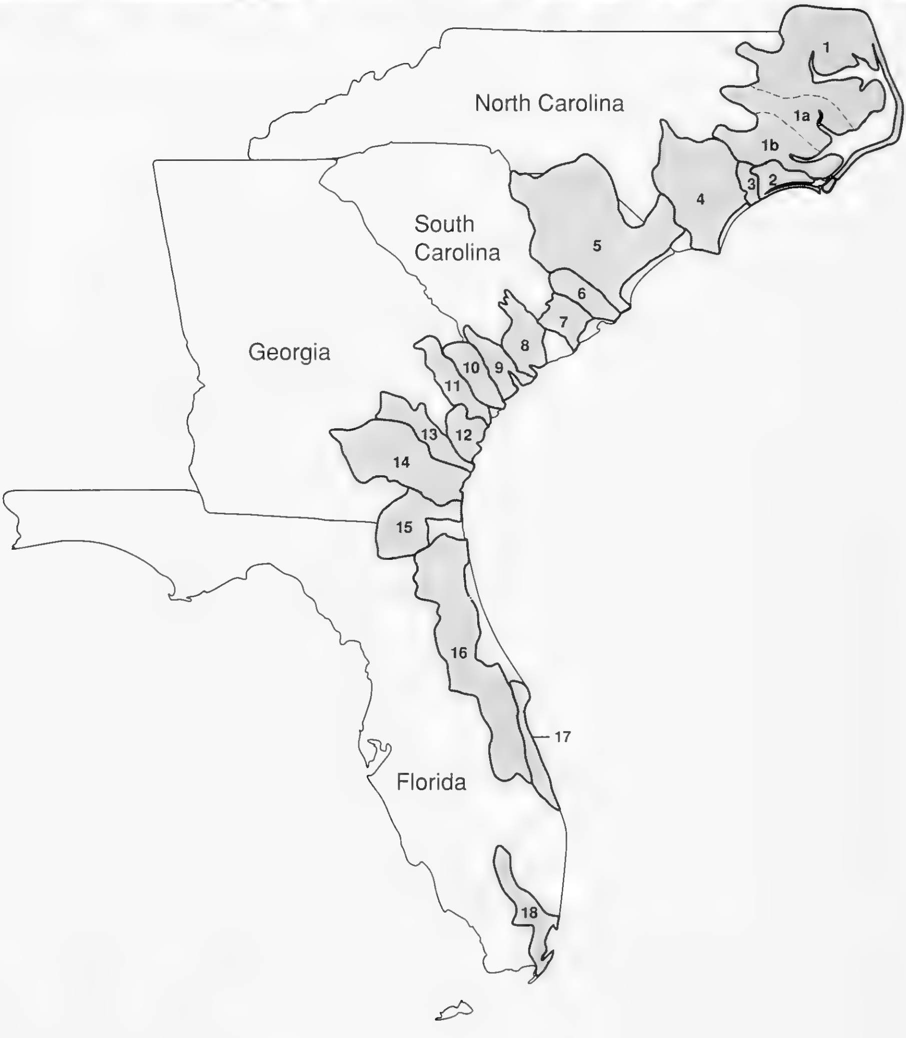
Middle Atlantic (Acres x 1,000) (cont.)

Estuary	Approved		Conditional		Restricted		Prohibited		Total		% Approved		% HL	
	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990
York River	*32*	*33*	*<1*	*–*	*6*	*9*	*4*	*–*	*42*	*42*	*77*	*78*	*23*	*22*
James River	*45*	*57*	*15*	*2*	*83*	*86*	*115*	*115*	*258*	*260*	*18*	*22*	*82*	*78*
Chester River	*39*	*34*	*–*	*5*	*1*	*1*	*4*	*4*	*43*	*43*	*90*	*79*	*10*	*21*
Choptank River	*7*	*–*	*–*	*8*	*1*	*<1*	*2*	*2*	*11*	*11*	*70*	*–*	*30*	*100*
Tangier/Pocomoke Sound	*232*	*195*	*2*	*7*	*<1*	*1*	*1*	*<1*	*235*	*204*	*98*	*96*	*2*	*4*
Other	*215*	*189*	*1*	*2*	*2*	*1*	*17*	*38*	*235*	*231*	*92*	*82*	*8*	*18*
Middle Atlantic Total	**4,480**	**4,221**	**152**	**217**	**218**	**217**	**596**	**688**	**5,446**	**5,343**	**82**	**79**	**18**	**21**
National Total	**11,401**	**10,863**	**1,462**	**1,571**	**636**	**462**	**3,127**	**4,257**	**16,626**	**17,153**	**69**	**63**	**31**	**37**

Abbreviations: HL, harvest-limited; –, no acreage.

Note: Not shown above are Non-shellfish/Non-productive classifications, which totaled 275,000 acres in 1985 and 354,000 acres in 1990. Sub-estuaries are in italics.

South Atlantic



Estuarine Drainage Areas

1 Albemarle/Pamlico Sounds
1a Pamlico/Pungo Rivers
1b Neuse River
2 Bogue Sound
3 New River
4 Cape Fear River
5 Winyah Bay
6 North Santee/South Santee Rivers
7 Charleston Harbor
8 St. Helena Sound
9 Broad River
10 Savannah River
11 Ossabaw Sound
12 St. Catherines/Sapelo Sounds
13 Altamaha River
14 St. Andrew/St. Simons Sounds
15 St. Marys River/Cumberland Sound
16 St. Johns River
17 Indian River
18 Biscayne Bay

Note: Sub-estuaries are in italics.

South Atlantic (Acres x 1,000)

Estuary	Approved		Conditional		Restricted		Prohibited		Total		% Approved		% HL	
	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990
Albemarle/Pamlico Sounds	1,206	1,204	1	2	–	–	264	303	1,471	1,509	82	80	18	20
Pamlico/Pungo Rivers	*449*	*486*	*3*	*2*	–	–	*64*	*54*	*516*	*543*	*87*	*90*	*13*	*10*
Neuse River	*72*	*53*	*2*	*3*	–	–	*36*	*35*	*110*	*91*	*65*	*58*	*35*	*42*
Bogue Sound	36	36	24	26	–	–	8	7	69	69	53	51	47	49
New River	13	14	–	–	–	–	9	9	23	23	–	60	41	40
Cape Fear River	9	9	–	2	–	–	18	14	27	25	33	37	67	63
Winyah Bay	3	3	<1	1	–	8	19	11	22	22	13	13	87	87
N. Santee/S. Santee Rivers	32	22	<1	<1	–	14	4	<1	36	36	89	61	11	39
Charleston Harbor	–	–	5	5	–	2	19	17	24	24	–	–	100	100
St. Helena Sound	155	116	1	<1	–	<1	5	<1	161	116	96	99	4	1
Broad River	3	3	<1	<1	–	<1	9	9	12	13	25	26	75	74
Savannah River	8	8	–	–	–	1	23	33	31	42	25	19	75	81
Ossabaw Sound	2	2	–	–	9	–	<1	9	10	10	15	16	85	84
St. Catherines/Sapelo Sds	20	15	–	–	1	–	23	28	44	44	44	36	56	64
Altamaha River	–	–	–	–	–	–	12	12	12	12	–	–	100	100

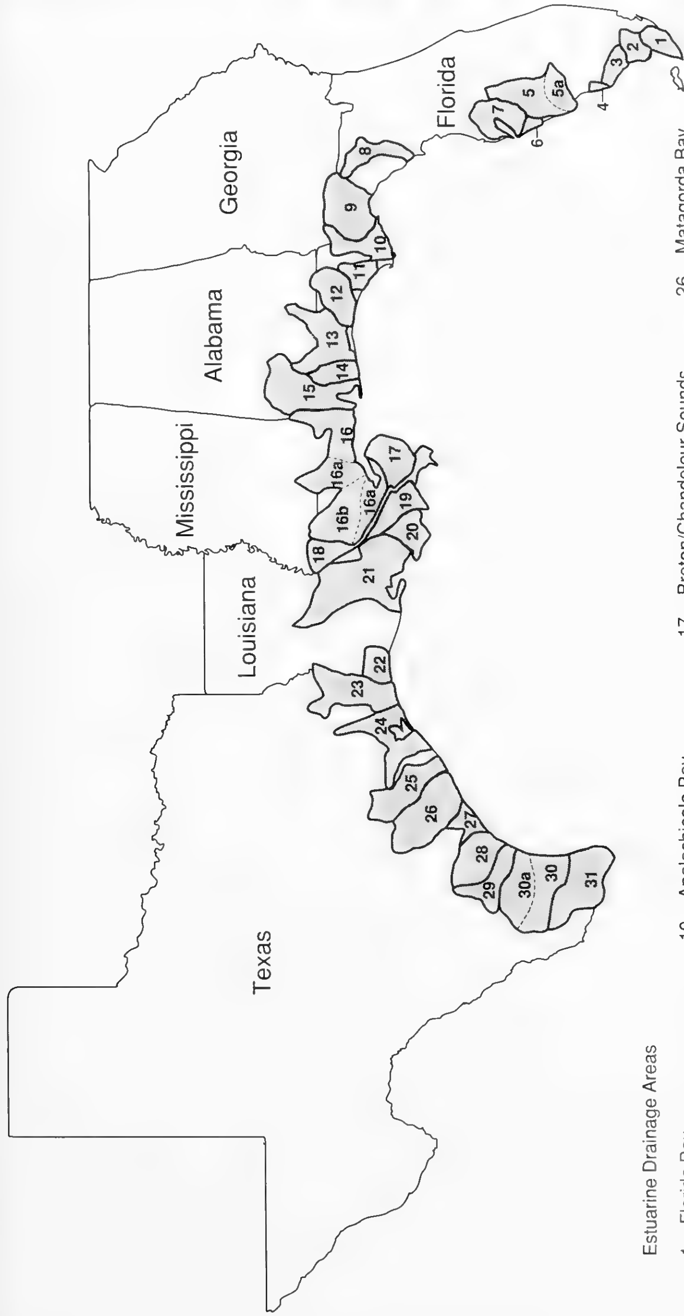
South Atlantic (Acres x 1,000) (cont.)

Estuary	Approved		Conditional		Restricted		Prohibited		Total		% Approved		% HL	
	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990
St. Andrew/St. Simons Sds	20	21	–	–	4	5	35	34	59	60	34	34	66	66
St. Marys River/Cumberland Sd	–	–	–	–	–	<1	–	–	–	–	–	–	–	–
St. Johns River	1	1	1	1	–	–	2	2	4	4	19	19	81	81
Indian River	22	22	20	46	–	57	27	29	69	153	32	14	68	86
Biscayne Bay	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Other	45	76	25	30	–	13	35	23	105	143	43	53	57	47
South Atlantic Total	**2,096**	**2,091**	**82**	**119**	**15**	**100**	**612**	**630**	**2,805**	**2,940**	**75**	**71**	**25**	**29**
National Total	**11,401**	**10,863**	**1,462**	**1,571**	**636**	**462**	**3,127**	**4,257**	**16,626**	**17,153**	**69**	**63**	**31**	**37**

Abbreviations: HL, harvest-limited; –, no acreage; Sd, sound.

Note: Not shown above are Non-shellfish/Non-productive areas, which totaled 479,000 acres in 1985 and 390,000 acres in 1990.

Gulf of Mexico



Estuarine Drainage Areas

1	Florida Bay
2	South Ten Thousand Islands
3	North Ten Thousand Islands
4	Rookery Bay
5	Charlotte Harbor
5a	*Caloosahatchee River*
6	Sarasota Bay
7	Tampa Bay
8	Suwannee River
9	Apalachee Bay
10	Apalachicola Bay
11	St. Andrew Bay
12	Choctawhatchee Bay
13	Pensacola Bay
14	Perdido Bay
15	Mobile Bay
16	Mississippi Sound
16a	*Lake Borgne*
16b	*Lake Pontchartrain*
17	Breton/Chandeleur Sounds
18	Mississippi River
19	Barataria Bay
20	Terrebonne/Timbalier Bays
21	Atchafalaya/Vermilion Bays
22	Calcasieu Lake
23	Sabine Lake
24	Galveston Bay
25	Brazos River
26	Matagorda Bay
27	San Antonio Bay
28	Aransas Bay
29	Corpus Christi Bay
30	Upper Laguna Madre
30a	*Baffin Bay*
31	Lower Laguna Madre

Note: Sub-estuaries are in italics.

Gulf of Mexico (Acres x 1,000)

Estuary	Approved		Conditional		Restricted		Prohibited		Total		% Approved		% HL	
	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990
Florida Bay	–	–	–	–	–	–	–	–	–	–	–	–	–	–
South Ten Thousand Islands	–	–	–	–	–	–	–	–	–	–	–	–	–	–
North Ten Thousand Islands	28	28	–	–	–	–	–	6	28	34	100	82	–	18
Rookery Bay	–	–	–	–	–	–	23	17	23	17	–	–	100	100
Charlotte Harbor	–	53	73	33	–	–	47	35	120	120	–	44	100	56
Caloosahatchee River	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sarasota Bay	–	–	3	3	–	–	20	20	23	23	–	–	100	100
Tampa Bay	40	38	–	16	–	–	32	45	72	98	55	38	45	62
Suwannee River	6	8	73	65	–	39	8	77	87	190	7	4	93	96
Apalachee Bay	3	3	14	15	–	7	7	2	24	28	13	12	87	88
Apalachicola Bay	<1	–	132	132	–	–	10	10	142	142	–	–	100	100
St. Andrew Bay	–	–	37	30	–	–	26	33	64	63	–	–	100	100
Choctawhatchee Bay	53	–	–	50	–	–	10	25	63	75	85	–	15	100
Pensacola Bay	43	–	–	46	–	–	54	53	97	99	44	–	56	100
Perdido Bay	–	–	–	–	–	–	17	17	17	17	–	–	100	100
Mobile Bay	–	–	211	211	–	–	<1	<1	211	211	–	–	100	100
Mississippi Sound	180	375	246	37	2	57	182	147	610	616	29	61	71	39
Lake Borgne	*169*	*170*	*12*	*21*	–	–	*19*	*13*	*200*	*203*	*84*	*83*	*16*	*17*
Lake Pontchartrain	–	–	–	–	*383*	–	*44*	*427*	*427*	*427*	–	–	*100*	*100*

Gulf of Mexico (Acres x 1,000) (cont.)

Estuary	Approved		Conditional		Restricted		Prohibited		Total		% Approved		% HL	
	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990
Breton/Chandeleur Sounds	1,024	1,029	38	38	–	–	58	41	1,120	1,107	91	93	9	7
Mississippi River	–	–	–	–	–	–	46	47	46	47	–	–	100	100
Barataria Bay	114	114	21	12	–	–	15	21	150	147	76	78	24	22
Terrebonne/Timbalier Bays	298	298	39	39	–	–	3	3	337	337	88	88	12	12
Atchfalaya/Vermilion Bays	122	127	172	177	–	–	385	384	678	688	18	18	82	82
Calcasieu Lake	11	26	–	19	–	–	40	47	52	92	22	28	78	72
Sabine Lake	–	–	–	–	–	–	69	69	69	69	–	–	100	100
Galveston Bay	175	145	–	43	–	–	184	215	359	403	49	36	51	64
Brazos River	5	1	–	–	–	–	2	6	7	7	73	14	27	86
Matagorda Bay	232	200	–	30	–	–	30	33	262	263	89	76	11	24
San Antonio Bay	241	172	4	64	–	–	16	27	260	263	93	65	7	35
Aransas Bay	183	179	–	–	–	–	41	36	223	215	82	83	18	17
Corpus Christi Bay	109	109	–	–	–	–	35	30	144	139	76	78	24	22
Upper Laguna Madre	417	191	–	–	–	–	5	217	422	408	99	47	1	53
Baffin Bay	*91*	*39*	–	–	–	–	*13*	*71*	*104*	*110*	*88*	*35*	*12*	*65*
Lower Laguna Madre	2	2	–	–	–	–	8	26	10	28	19	7	81	93
Other	116	130	75	72	–	–	198	203	389	405	30	32	70	68
Gulf of Mexico Total	**3,662**	**3,434**	**1,147**	**1,153**	**385**	**103**	**1,649**	**2,405**	**6,843**	**7,095**	**54**	**48**	**46**	**52**
National Total	**11,401**	**10,863**	**1,462**	**1,571**	**636**	**462**	**3,127**	**4,257**	**16,626**	**17,153**	**69**	**63**	**31**	**37**

Abbreviations: HL, harvest-limited; –, no acreage.

Note: Non-shellfish/Non-productive classifications totaling 833,000 acres in 1985 and 706,000 acres in 1990 are not shown. Sub-estuaries are in italics.

Pacific

Estuarine Drainage Areas

1 Tijuana Estuary
2 San Diego Bay
3 Mission Bay
4 Newport Bay
5 San Pedro Bay
5a Alamitos Bay
5b Anaheim Bay
6 Santa Monica Bay
7 Morro Bay
8 Monterey Bay
8a Elkhorn Slough
9 San Francisco Bay
9a Central San Francisco/ San Pablo/Suisun Bays
10 Drakes Estero
11 Tomales Bay
12 Eel River
13 Humboldt Bay
14 Klamath River
15 Rogue River
16 Coos Bay
17 Umpqua River (old Winchester Bay)
18 Siuslaw River
19 Alsea River
20 Yaquina Bay
21 Siletz Bay
22 Netarts Bay
23 Tillamook Bay
24 Nehalem River
25 Columbia River
26 Willapa Bay
27 Grays Harbor
28 Puget Sound
28a Hood Canal
28b Skagit Bay

Note: Sub-estuaries are in italics.

Pacific (Acres x 1,000)

Estuary	Approved		Conditional		Restricted		Prohibited		Total		% Approved		% HL	
	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990
Tijuana Estuary	–	–	–	–	–	–	–	–	–	–	–	–	–	–
San Diego Bay	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Mission Bay	–	–	–	–	–	–	–	–	–	–	–	–	–	–
San Pedro Bay	–	–	–	–	–	–	–	15	–	15	–	–	–	100
Alamitos Bay	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Anaheim Bay	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Santa Monica Bay	–	–	–	–	–	–	–	1	–	1	–	–	–	–
Morro Bay	–	–	1	1	–	–	1	1	2	2	–	–	100	100
Monterey Bay	–	–	–	–	1	<1	<1	1	1	1	–	–	100	100
Elkhorn Slough	–	–	–	–	–	–	–	–	–	–	–	–	–	–
San Francisco Bay	–	–	1	1	–	–	16	16	17	17	–	–	100	100
Central San Francisco/ San Pablo/Suisun Bays	–	–	–	–	–	–	*65*	*65*	*65*	*65*	–	–	*100*	*100*
Drakes Estero	2	2	1	1	–	–	–	–	3	3	71	77	29	23
Tomales Bay	–	–	5	5	1	1	–	1	6	7	–	–	100	100
Eel River	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Humboldt Bay	–	–	5	5	–	–	12	12	16	16	–	–	100	100
Klamath River	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rogue River	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Coos Bay	3	1	6	7	–	–	2	3	11	11	27	11	73	89
Umpqua River	3	2	–	<1	–	1	3	2	6	6	56	41	44	59

Pacific (Acres x 1,000) (cont.)

Estuary	Approved		Conditional		Restricted		Prohibited		Total		% Approved		% HL	
	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990
Siuslaw River	–	–	–	–	–	–	2	–	2	–	–	–	100	–
Alsea River	–	–	–	–	–	–	2	–	2	–	–	–	100	–
Yaquina Bay	2	–	–	2	–	–	2	2	4	4	56	–	44	100
Siletz Bay	1	–	–	–	–	–	<1	–	1	–	68	–	32	–
Netarts Bay	2	2	–	–	–	–	–	–	2	2	100	100	–	–
Tillamook Bay	–	–	7	7	–	–	3	3	9	9	–	–	100	100
Nehalem River	2	2	–	–	–	–	<1	2	2	3	88	49	12	51
Columbia River	–	–	–	–	–	–	–	2	–	2	–	–	–	100
Willapa Bay	87	85	–	–	–	2	3	3	90	90	97	95	3	5
Grays Harbor	–	–	43	43	–	–	17	17	60	60	–	–	100	100
Puget Sound	34	34	<1	2	–	–	22	27	57	63	60	53	40	47
Hood Canal	*9*	*8*	*2*	*<1*	–	*<1*	*1*	*2*	*12*	*11*	*79*	*76*	*21*	*24*
Skagit Bay	*17*	*3*	*<1*	*<1*	–	*26*	*7*	*7*	*24*	*36*	*71*	*8*	*29*	*92*
Other	–	–	–	–	–	–	–	4	1	4	63	10	38	90
Total	**162**	**139**	**71**	**73**	**2**	**30**	**158**	**186**	**393**	**428**	**42**	**33**	**58**	**67**
National Total	**11,401**	**10,863**	**1,462**	**1,571**	**636**	**462**	**3,127**	**4,257**	**16,626**	**17,153**	**69**	**63**	**31**	**37**

Abbreviations: HL, harvest-limited; –, no acreage.

Note: Non-shellfish/Non-productive classifications totaling 2,288,000 acres in 1985 and 2,442,000 acres in 1990 are not shown. Sub-estuaries are in italics.

Alaska and Hawaii

Alaska Shellfish-Growing Areas

1 Southeast
2 Yakutat
3 Prince William Sound
4 Cook Inlet
5 Kodiak

Alaska and Hawaii (Acres x 1,000) [a]

State/Area	Approved		Conditional		Restricted		Prohibited		Total		% Approved		% HL	
	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990	1985	1990
Alaska														
Southeast	–	31	–	–	–	–	–	–	–	31	–	100	–	–
Yakutat	–	<1	–	–	–	–	–	–	–	–	–	–	–	–
Prince William Sound	–	2	–	–	–	–	–	–	–	2	–	100	–	–
Cook Inlet	–	13	–	–	–	–	–	–	–	13	–	100	–	–
Kodiak	–	151	–	–	–	–	–	–	–	151	–	100	–	–
Other	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Alaska Total	**0**	**197**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**197**	**0**	**100**	**0**	**0**
Hawaii (All Areas)	–	–	–	–	–	–	–	18	–	18	–	–	–	100
Hawaii Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**18**	**0**	**18**	**0**	**100**	**0**	**100**
National Total	**11,401**	**10,863**	**1,462**	**1,571**	**636**	**462**	**3,127**	**4,257**	**16,626**	**17,153**	**69**	**63**	**31**	**37**

Abbreviations: HL, harvest-limited; –, no acreage.

Note: Non-shellfish/Non-productive classifications for Alaska totaling zero acres in 1985 and 7,000 acres in 1990 are not shown. Hawaii did not have Non-shellfish/Non-productive acreage in 1985 or 1990.

a. Alaska and Hawaii are located in the Pacific region but are listed separately since they are not part of NOAA's National Estuarine Inventory.

North Atlantic (Acres x 1,000)

Estuary	Point				Nonpoint					Upstream				
	STP	CSO	DD	IND	SEP	URO	ARO	WL	BTG	STP	CSO	URO	ARO	WL
Passamaquoddy Bay	4	–	–	–	2	–	–	<1	–	–	–	–	–	–
Englishman Bay	3	–	–	–	–	–	–	–	–	–	–	–	–	–
Narraguagas Bay	–	–	–	–	1	–	–	–	–	–	–	–	–	–
Blue Hill Bay	–	–	–	–	<1	–	–	–	–	–	–	–	–	–
Penobscot Bay	39	–	<1	2	39	7	–	–	–	–	–	–	–	–
Muscongus Bay	4	–	–	<1	3	2	–	–	–	–	–	–	–	–
Sheepscot Bay	15	–	–	6	12	1	–	–	<1	–	–	–	–	–
Casco Bay	23	–	–	–	10	2	–	–	17	–	–	–	–	–
Saco Bay	8	–	–	1	<1	4	–	–	–	–	–	–	–	–
Great Bay	2	–	–	1	2	1	–	–	–	–	–	–	–	–
Merrimack River	2	–	–	<1	<1	<1	–	<1	<1	2	–	2	–	–
Masachusetts Bay	89	9	–	2	1	12	–	<1	4	–	–	1	–	–
Boston Bay	*2*	*11*	–	*6*	*<1*	*29*	–	*1*	*28*	–	–	–	–	–
Cape Cod Bay	71	<1	<1	<1	2	3	1	6	2	–	–	–	–	–
Other	21	<1	–	3	19	14	4	12	4	–	–	–	–	–
North Atlantic Total	**238**	**20**	**–**	**21**	**91**	**75**	**5**	**19**	**55**	**2**	**–**	**3**	**–**	**–**
% Harvest-Limited Acreage	**68**	**6**	**0**	**6**	**26**	**21**	**1**	**5**	**16**	**1**	**0**	**1**	**0**	**0**
National Total	**2,299**	**382**	**1,011**	**1,047**	**2,325**	**2,385**	**699**	**1,552**	**1,125**	**1,337**	**142**	**1,013**	**312**	**269**
% Harvest-Limited Acreage	**36**	**6**	**16**	**16**	**36**	**37**	**11**	**24**	**18**	**21**	**2**	**16**	**5**	**4**

Abbreviations: STP, sewage treatment plant; CSO, combined sewer outfall; DD, direct discharge; IND, industry; SEP, septics; URO, urban runoff; ARO, agricultural runoff; WL, wildlife; BTG, boating; –, no acreage affected.

Note: Sub-estuaries are in italics

Middle Atlantic (Acres x1,000)

Estuary	Point				Nonpoint					Upstream				
	STP	CSO	DD	IND	SEP	URO	ARO	WL	BTG	STP	CSO	URO	ARO	WL
Buzzards Bay	10	4	<1	<1	8	11	–	8	9	11	–	10	–	10
Narragansett Bay	23	7	9	6	2	7	1	<1	16	11	–	17	–	–
Gardiners Bay	1	1	–	–	1	1	1	2	1	–	–	–	–	–
Long Island Sound	139	84	7	9	10	122	2	8	46	49	3	9	–	2
Connecticut River	*4*	–	–	–	–	–	–	–	*5*	*2*	–	–	–	–
Great South Bay	<1	–	–	–	5	41	3	6	29	–	–	–	–	–
Hudson River/Raritan Bay	173	128	68	16	7	157	4	–	1	–	2	4	–	–
Barnegat Bay	–	–	–	–	1	16	–	–	13	–	–	1	1	–
New Jersey Inland Bays	–	–	–	–	5	19	–	6	11	–	–	–	–	–
Delaware Bay	25	–	–	3	29	19	30	35	4	5	–	–	–	–
Delaware Inland Bays	4	–	–	–	3	5	<1	–	<1	–	–	–	–	–
Chincoteague Bay	1	–	–	1	1	–	<1	–	2	–	–	–	–	–
Chesapeake Bay	17	–	–	11	24	40	36	26	36	10	–	15	–	–
Patuxent River	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Potomac River	*6*	–	*<1*	*1*	*9*	*<1*	*18*	*<1*	*4*	–	*<1*	–	–	–
Rappahannock River	*3*	–	–	*1*	*10*	*<1*	*12*	–	*12*	–	–	–	–	–
York River	*1*	–	–	*5*	*2*	*<1*	*<1*	*<1*	*6*	–	–	–	–	–

Middle Atlantic (Acres x1,000) (cont.)

Estuary	Point				Nonpoint					Upstream				
	STP	CSO	DD	IND	SEP	URO	ARO	WL	BTG	STP	CSO	URO	ARO	WL
James River	*181*	–	–	*155*	*3*	*158*	*9*	–	*130*	*16*	–	*16*	–	*16*
Chester River	*1*	–	–	*<1*	*5*	*<1*	*7*	*7*	*<1*	–	–	–	–	–
Choptank River	*2*	–	–	–	–	–	*9*	*1*	–	–	–	–	–	–
Tangier/Pocomoke Sounds	*2*	–	–	*<1*	*<1*	–	*6*	*6*	*2*	–	–	–	–	–
Other	51	–	–	16	8	59	4	7	34	–	–	–	–	–
Middle Atlantic Total	**644**	**224**	**84**	**224**	**133**	**655**	**142**	**112**	**361**	**104**	**5**	**72**	**1**	**28**
% Harvest-Limited	**53**	**18**	**7**	**18**	**11**	**54**	**12**	**9**	**30**	**9**	**0**	**6**	**0**	**2**
National Total	**2,299**	**382**	**1,011**	**1,047**	**2,325**	**2,385**	**699**	**1,552**	**1,125**	**1,337**	**142**	**1,013**	**312**	**269**
% Harvest-Limited	**36**	**6**	**16**	**16**	**36**	**37**	**11**	**24**	**18**	**21**	**2**	**16**	**5**	**4**

Abbreviations: STP, sewage treatment plant; CSO, combined sewer outfall; DD, direct discharge; IND, industry; SEP, septics; URO, Urban Runoff; ARO, agricultural runoff WL, wildlife; BTG, boating; –, no acreage affected.

Note: Sub-estuaries are in italics.

South Atlantic (Acres x 1,000)

Estuary	Point				Nonpoint					Upstream				
	STP	CSO	DD	IND	SEP	URO	ARO	WL	BTG	STP	CSO	URO	ARO	WL
Albemarle/Pamlico Sounds	100	–	–	74	22	11	147	145	25	–	–	–	–	–
Pamlico/Pungo Rivers	*6*	–	–	*1*	*7*	*4*	*49*	*3*	*1*	–	–	–	–	–
Neuse River	*32*	–	–	*1*	*1*	*32*	*5*	–	*1*	–	–	–	–	–
Bogue Sound	3	–	–	2	2	16	21	<1	6	<1	–	–	–	–
New River	9	–	–	–	9	<1	<1	–	<1	–	–	–	–	–
Cape Fear River	14	–	–	4	2	14	–	–	15	–	–	–	–	–
Winyah Bay	3	–	–	13	–	3	–	1	–	5	–	5	–	19
N. Santee/S. Santee Rivers	–	–	<1	<1	<1	–	–	14	<1	–	–	–	–	–
Charleston Harbor	22	–	–	22	19	22	–	–	22	–	–	–	–	–
St. Helena Sound	<1	–	–	–	<1	<1	1	<1	<1	–	–	–	–	<1
Broad River	8	–	–	1	–	–	1	–	1	–	–	–	–	–
Savannah River	31	–	–	31	1	31	1	1	–	3	–	2	–	–
Ossabaw Sound	–	–	–	–	<1	–	–	9	–	–	–	–	–	–
St. Catherines/Sapelo Sounds	–	–	5	–	21	<1	4	23	21	–	–	–	–	4
Altamaha River	12	–	–	–	12	–	–	–	12	–	–	–	–	12
St. Andrew/St. Simons Sounds	5	–	–	23	4	4	4	1	4	–	–	–	–	–
St. Marys /Cumberland Sounds	–	–	–	–	–	–	–	–	–	–	–	–	–	–

South Atlantic (Acres x 1,000) (cont.)

Estuary	Point				Nonpoint					Upstream				
	STP	CSO	DD	IND	SEP	URO	ARO	WL	BTG	STP	CSO	URO	ARO	WL
St. Johns River	4	–	–	–	4	4	–	4	–	–	–	–	–	–
Indian River	90	–	–	–	125	105	–	68	15	–	–	–	–	–
Biscayne Bay	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Other	35	–	–	7	59	45	2	37	23	1	–	–	–	–
South Atlantic Total	**374**	**–**	**5**	**179**	**288**	**291**	**235**	**306**	**146**	**9**	**–**	**7**	**0**	**35**
% Harvest-Limited	**44**	**0**	**1**	**21**	**34**	**34**	**28**	**36**	**17**	**1**	**0**	**1**	**0**	**4**
National Total	**2,299**	**382**	**1,011**	**1,047**	**2,325**	**2,385**	**699**	**1,552**	**1,125**	**1,337**	**142**	**1,013**	**312**	**269**
% Harvest-Limited	**36**	**6**	**16**	**16**	**36**	**37**	**11**	**24**	**18**	**21**	**2**	**16**	**5**	**4**

Abbreviations: STP, sewage treatment plant; CSO, combined sewer outfall; DD, direct discharge; IND, industry; SEP, septics; URO, urban runoff; ARO, agricultural runoff; WL, wildlife; BTG, boating; –, no acreage affected.

Note: Sub-estuaries are in italics

Gulf of Mexico (Acres x 1,000)

Estuary	Point				Nonpoint					Upstream				
	STP	CSO	DD	IND	SEP	URO	ARO	WL	BTG	STP	CSO	URO	ARO	WL
Florida Bay	–	–	–	–	–	–	–	–	–	–	–	–	–	–
SouthTen Thousand Islands	–	–	–	–	–	–	–	–	–	–	–	–	–	–
North Ten Thousand Islands	6	–	–	6	–	–	–	–	–	–	–	–	–	–
Rookery Bay	17	–	–	17	–	–	–	–	–	–	–	–	–	–
Charlotte Harbor	35	–	–	1	66	35	–	40	23	–	–	–	–	–
Caloosahatchee River	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sarasota Bay	18	–	–	–	23	23	–	–	23	–	–	–	–	–
Tampa Bay	53	–	–	8	16	38	–	10	<1	–	–	–	–	–
Suwannee River	6	–	–	–	182	116	4	176	–	–	–	–	–	–
Apalachee Bay	–	–	–	–	24	11	–	25	1	–	7	–	–	–
Apalachicola Bay	8	8	2	8	141	10	–	139	8	131	–	–	–	141
St. Andrew Bay	55	–	–	36	38	42	–	34	<1	–	–	–	–	–
Choctawhatchee Bay	65	–	–	–	69	65	–	75	–	–	–	–	–	–
Pensacola Bay	56	–	–	88	56	49	–	13	–	–	–	–	–	–
Perdido Bay	–	–	–	–	–	–	17	–	–	–	–	–	–	–
Mobile Bay	<1	–	–	–	<1	–	<1	–	–	–	3	211	211	–
Mississippi Sound	112	–	–	39	16	36	–	45	129	3	3	10	12	–
Lake Borgne	–	–	–	–	*4*	–	–	–	–	*24*	*10*	*24*	–	–
Lake Pontchartrain	*44*	–	*383*	–	–	*427*	–	–	–	*383*	–	–	–	–
Breton/Chandeleur Sounds	–	–	21	–	66	2	18	19	9	57	–	57	<1	<1
Mississippi River	47	–	–	47	–	47	–	–	47	–	–	–	–	–

Gulf of Mexico (Acres x 1,000) (cont.)

Estuary	Point				Nonpoint					Upstream				
	STP	CSO	DD	IND	SEP	URO	ARO	WL	BTG	STP	CSO	URO	ARO	WL
Barataria Bay	3	–	1	–	2	–	19	1	–	–	–	–	–	–
Terrebonne/Timbalier Bays	1	–	21	–	21	–	–	2	–	2	–	–	–	–
Atchfalaya/Vermilion Bays	11	203	483	13	483	–	–	351	1	530	–	465	–	–
Calcasieu Lake	–	–	4	–	<1	1	21	39	9	–	–	7	–	3
Sabine Lake	–	–	–	–	–	–	5	3	–	2	–	–	–	–
Galveston Bay	104	–	–	45	255	89	195	78	18	–	114	10	114	–
Brazos River	2	–	–	6	–	2	2	5	–	–	–	–	2	2
Matagorda Bay	10	–	1	14	56	1	17	9	37	–	–	–	14	–
San Antonio Bay	16	–	–	–	64	4	–	–	12	–	–	–	80	64
Aransas Bay	28	–	–	–	7	6	3	31	3	–	–	–	2	–
Corpus Christi Bay	30	–	–	–	17	24	–	–	–	–	–	–	–	–
Upper Laguna Madre	3	–	–	–	1	3	–	–	7	–	–	–	–	–
Baffin Bay	–	–	–	–	*71*	–	–	–	–	–	–	–	–	–
Lower Laguna Madre	9	–	–	<1	–	8	–	–	7	–	–	–	–	–
Other	234	–	4	201	85	237	–	20	173	42	–	9	–	–
Gulf of Mexico Total	**973**	**211**	**920**	**529**	**1,763**	**1,276**	**301**	**1,115**	**507**	**1,174**	**137**	**793**	**435**	**210**
% Harvest-Limited Acreage	**27**	**6**	**25**	**14**	**48**	**35**	**8**	**30**	**14**	**32**	**4**	**22**	**12**	**6**
National Total	**2,299**	**382**	**1,011**	**1,047**	**2,325**	**2,385**	**699**	**1,552**	**1,125**	**1,337**	**142**	**1,013**	**312**	**269**
% Harvest-Limited Acreage	**36**	**6**	**16**	**16**	**36**	**37**	**11**	**24**	**18**	**21**	**2**	**16**	**5**	**4**

Abbreviations: STP, sewage treatment plant; CSO, combined sewer outfall; DD, direct discharge; IND, industry; SEP, septics; URO, urban runoff; ARO, agricultural runoff; WL, wildlife; BTG, boating; –, no acreage affected.

Note: Sub-estuaries are in italics

Pacific (Acres x 1,000)

Estuary	Point				Nonpoint					Upstream				
	STP	CSO	DD	IND	SEP	URO	ARO	WL	BTG	STP	CSO	URO	ARO	WL
Tijuana Estuary	–	–	–	–	–	–	–	–	–	–	–	–	–	–
San Diego Bay	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Mission Bay	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Newport Bay	–	–	–	–	–	–	–	–	–	–	–	–	–	–
San Pedro Bay	–	–	–	15	–	15	–	–	15	–	–	–	–	–
Alamitos Bay	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Anaheim Bay	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Santa Monica Bay	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Morro Bay	–	–	–	–	1	1	–	2	1	–	–	–	–	–
Monterey Bay	1	–	–	–	–	<1	–	<1	<1	–	–	–	–	–
Elkhorn Slough	–	–	–	–	–	–	–	–	–	–	–	–	–	–
San Francisco Bay	2	–	–	7	–	9	–	–	8	–	–	–	–	–
Central San Francisco/ San Pablo/Suisun Bays	–	–	–	*65*	–	–	–	–	–	–	–	–	–	–
Drakes Estero	–	–	–	–	–	–	1	–	–	–	–	–	–	–
Tomales Bay	1	–	–	–	6	1	1	–	1	–	–	–	–	–
Humboldt Bay	9	–	–	–	5	–	17	17	–	–	–	–	–	–
Klamath River	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rogue River	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Coos Bay	1	–	5	–	3	7	–	–	2	1	–	–	–	–

Pacific (Acres x 1,000) (cont.)

Estuary	Point				Nonpoint					Upstream				
	STP	CSO	DD	IND	SEP	URO	ARO	WL	BTG	STP	CSO	URO	ARO	WL
Umpqua River	2	–	–	–	2	3	–	–	3	1	–	<1	–	–
Siuslaw River	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Alsea River	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Yaquina Bay	1	–	–	–	2	1	–	–	1	–	–	–	–	–
Siletz Bay	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Netarts Bay	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tillamook Bay	–	–	1	–	–	–	8	–	1	–	–	–	–	–
Nehalem River	<1	–	–	–	2	–	–	–	–	–	–	–	–	–
Columbia River	–	–	–	–	–	2	–	–	–	–	–	–	–	–
Willapa Bay	3	–	–	3	2	3	–	–	–	–	–	–	–	–
Grays Harbor	17	–	–	17	–	17	–	–	–	43	–	43	–	–
Puget Sound	25	–	–	13	2	25	<1	2	8	–	–	–	–	–
Hood Canal	*–*	*–*	*–*	*–*	*2*	*–*	*<1*	*<1*	*1*	–	–	–	–	–
Skagit Bay	*9*	*–*	*–*	*3*	*30*	*7*	*14*	*–*	*–*	–	–	–	–	–
Other	3	–	–	–	–	1	<1	<1	–	–	–	–	–	–
Pacific Total	**74**	**–**	**6**	**123**	**57**	**92**	**41**	**21**	**41**	**45**	**–**	**43**	**–**	**–**
% Harvest-Limited	**26**	**0**	**2**	**43**	**20**	**32**	**14**	**7**	**14**	**16**	**0**	**15**	**0**	**0**
National Total	**2,299**	**382**	**1,011**	**1,047**	**2,325**	**2,385**	**699**	**1,552**	**1,125**	**1,337**	**142**	**1,013**	**312**	**269**
% Harvest-Limited	**36**	**6**	**16**	**16**	**36**	**37**	**11**	**24**	**18**	**21**	**2**	**16**	**5**	**4**

Abbreviations: STP, sewage treatment plant; CSO, combined sewer outfall; DD, direct discharge; IND, industry; SEP, septics; URO, urban runoff; ARO, agricultural runoff; WL, wildlife; BTG, boating; –, no acreage affected.

Note: Sub-estuaries are in italics

Alaska and Hawaii (Acres x 1,000)[a]

State/Area	Point				Nonpoint					Upstream				
	STP	CSO	DD	IND	SEP	URO	ARO	WL	BTG	STP	CSO	URO	ARO	WL
Alaska														
Southeast	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Yakutat	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Prince William Sound	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cook Inlet	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Kodiak	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Other	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Alaska Total	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**
% Harvest-Limited	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**
Hawaii (All Areas)	1	–	–	6	–	18	–	–	6	–	–	–	–	–
Hawaii Total	**1**	**–**	**–**	**6**	**–**	**18**	**–**	**–**	**6**	**–**	**–**	**–**	**–**	**–**
% Harvest-Limited	**6**	**0**	**0**	**33**	**0**	**100**	**0**	**0**	**33**	**0**	**0**	**0**	**0**	**0**
National Total	**2,299**	**382**	**1,011**	**1,047**	**2,325**	**2,385**	**699**	**1,552**	**1,125**	**1,337**	**142**	**1,013**	**312**	**269**
% Harvest-Limited	**36**	**6**	**16**	**16**	**36**	**37**	**11**	**24**	**18**	**21**	**2**	**16**	**5**	**4**

Abbreviations: STP, sewage treatment plant; CSO, combined sewer outfall; DD, direct discharge; IND, industry; SEP, septics; URO, urban runoff; ARO, agricultural runoff; WL, wildlife; BTG, boating; –, no acreage affected.

a. Alaska and Hawaii are located in the Pacific region but are listed separately since they are not part of NOAA's National Estuarine Inventory.

Landings by State (Pounds x 1,000)

Region/State	Oyster Landings					Clam Landings				
	1985	1986	1987	1988	1989	1985	1986	1987	1988	1989
North Atlantic										
Maine	49	138	116	75	69	4,486	5,171	4,457	3,105	2,962
New Hampshire	0	0	0	0	0	0	0	0	0	0
Massachusetts	46	88	80	40	44	10,570	9,466	6,806	6,974	5,375
Total	**95**	**226**	**196**	**115**	**113**	**15,056**	**14,637**	**11,263**	**10,079**	**8,337**
Middle Atlantic										
Rhode Island	0	6	2	1	2	5,973	5,677	4,977	4,352	4,073
Connecticut	864	891	537	1,090	1,932	845	754	596	312	710
New York	299	264	174	324	339	10,010	14,633	5,879	5,795	9,233
New Jersey	293	105	15	0	0	63,438	62,137	61,809	56.095	71,106
Delaware	39	0	0	0	0	21	24	20	36	34
Maryland	3,518	6,828	3,649	2,060	2,160	23,306	21,456	23,192	21,598	8,422
Virginia	4,526	5,600	4,822	2,927	2,000	13,989	13,125	9,723	11,991	8,885
Total	**9,539**	**13,694**	**9,199**	**6,402**	**6,433**	**117,582**	**117,806**	**106,196**	**100,179**	**102,463**
South Atlantic										
North Carolina	546	745	1,426	913	530	1,335	1,357	1,207	998	1,295
South Carolina	1,038	568	315	228	294	194	242	172	202	108
Georgia	37	4	9	35	46	7	17	34	64	12
Florida	28	108	110	152	134	1,536	1,442	1,096	711	306
Total	**1,649**	**1,425**	**1,860**	**1,328**	**1,004**	**3,072**	**3,058**	**2,509**	**1,975**	**1,721**

Landings by State (Pounds x 1,000) (cont.)

Region/State	Oyster Landings					Clam Landings				
	1985	1986	1987	1988	1989	1985	1986	1987	1988	1989
Gulf of Mexico										
Florida	4,393	2,021	3,682	2,065	1,479	215	66	16	37	18
Alabama	1,277	946	88	103	10	0	0	0	0	0
Mississippi	1,193	1,202	132	147	100	0	0	0	0	0
Louisiana	14,123	12,316	10,769	21,917	8,673	0	0	0	0	0
Texas	5,134	5,649	2,897	2,270	1,980	0	0	0	0	0
Total	**26,120**	**22,134**	**17,568**	**26,502**	**12,242**	**215**	**66**	**16**	**37**	**18**
Pacific Coast										
California	1,209	1,131	1,138	1,172	1,458	129	79	123	440	40
Oregon	424	428	425	458	402	99	79	35	45	64
Washington	5,992	8,705	9,453	8,791	8,982	8,155	9,062	9,963	9,941	8,645
Alaska	*N/A*	*N/A*	*N/A*	*N/A*	106	434	418	71	240	204
Total	**7,625**	**10,264**	**11,016**	**10,421**	**10,948**	**8,817**	**9,638**	**10,192**	**10,666**	**8,953**
National Total	**45,028**	**47,743**	**39,839**	**44,768**	**30,740**	**144,742**	**145,204**	**130,175**	**122,936**	**121,492**

Abbreviations: N/A, Not Available.

Note: No commercial landings were reported in Hawaii between 1985 and 1989.

Landings by State (Pounds x 1,000) (cont.)

Region/State	Scallop Landings					Mussel Landings				
	1985	**1986**	**1987**	**1988**	**1989**	**1985**	**1986**	**1987**	**1988**	**1989**
North Atlantic										
Maine	813	721	1,239	1,311	1,715	6,123	6,640	6,615	6,269	4,759
New Hampshire	0	17	0	0	0	0	0	0	0	0
Massachusetts	9,890	10,964	16,878	17,170	18,553	N/A	N/A	N/A	N/A	N/A
Total	**10,703**	**11,702**	**18,117**	**18,481**	**20,268**	**6,123**	**6,640**	**6,615**	**6,269**	**4,759**
Middle Atlantic										
Rhode Island	22	0	0	0	0	0	0	0	0	0
Connecticut	10	72	130	0	0	0	0	0	0	0
New York	269	187	107	267	40	154	274	108	800	585
New Jersey	1,754	2,143	3,451	3,164	3,986	0	0	8	5	14
Delaware	0	0	0	0	0	0	0	0	0	0
Maryland	0	2	62	85	20	0	0	0	0	0
Virginia	2,868	4,261	7,291	6,545	7,702	0	0	0	0	0
Total	**4,923**	**6,665**	**11,041**	**10,061**	**11,748**	**154**	**274**	**116**	**805**	**599**
South Atlantic										
North Carolina	456	301	155	39	84	0	0	0	0	0
South Carolina	0	0	0	0	0	0	0	0	0	0
Georgia	0	0	0	0	0	0	0	0	0	0
Florida	9,917	1,575	10,934	12,039	3,350	0	0	0	0	0
Total	**10,373**	**1,876**	**11,089**	**12,078**	**3,434**	**0**	**0**	**0**	**0**	**0**

Landings by State (Pounds x 1,000) (cont.)

Region/State	Scallop Landings					Mussel Landings				
	1985	1986	1987	1988	1989	1985	1986	1987	1988	1989
Gulf of Mexico										
Florida	N/A	5	19	512	1,511	0	0	0	0	0
Alabama	0	0	0	0	0	0	0	0	0	0
Mississippi	0	0	0	0	0	0	0	0	0	0
Louisiana	0	0	0	0	0	0	0	0	0	0
Texas	0	5	0	0	1	0	0	0	0	0
Total	**0**	**10**	**19**	**512**	**1,512**	**0**	**0**	**0**	**0**	**0**
Pacific Coast										
California	0	0	0	0	0	0	335	287	151	163
Oregon	205	26	14	8	0	40	38	49	49	60
Washington	13	9	10	15	90	255	297	284	486	479
Alaska	677	645	677	233	313	0	0	0	0	65
Total	**895**	**680**	**701**	**256**	**403**	**295**	**670**	**620**	**686**	**767**
National Total	**26,894**	**20,933**	**40,967**	**41,388**	**37,365**	**6,572**	**7,584**	**7,351**	**7,760**	**6,125**

Abbreviations: N/A, Not Available.
Note: No commercial landings were reported in Hawaii between 1985 and 1989.

State	Dollars per Acre[a,b]		Total Classified Acres per Sampling Station[b]	
	1985	1990	1985	1990
Maine	**0.07**	**0.08**	**413**	**714**
New Hampshire	**0.22**	1.66	**619**	**481**
Massachusetts	0.96	**0.33**	1,357	3,474
Rhode Island	**0.22**	2.03	**567**	**567**
Connecticut	0.24	1.05	1,057	**888**
New York	**0.16**	0.53	1,096	**718**
New Jersey	1.48	1.20	**99**	**167**
Delaware	0.26	**0.25**	1,679	1,686
Maryland	0.36	**0.44**	982	1,937
Virginia	0.34	**0.38**	**414**	**788**
North Carolina	**0.10**	**0.27**	**863**	1,610
South Carolina	1.45	1.39	**750**	**775**
Georgia	**0.17**	3.13	949	**740**
Florida	0.38	**0.29**	**772**	969
Alabama	**0.01**	**0.31**	4,597	4,818
Mississippi	**0.06**	0.48	3,608	3,122
Louisiana	**0.19**	**0.18**	4,797	4,243
Texas	**0.16**	**0.17**	4,113	2,751
California	2.65	2.71	13,750	2,150
Oregon	1.61	2.08	**451**	**367**
Washington	4.19	5.73	**97**	**33**
Alaska	N/A	N/A	N/A	1,165
Hawaii	N/A	N/A	N/A	2,250
Average	*0.34*	*0.47*	*754*	*847*

Abbreviations: N/A, Not Available.

a. Dollar values are in constant 1989 values.

b. Bold values indicate numbers lower than the median.

Approved Waters Shellfish may be harvested for direct marketing.

Classified Shellfish-Growing Waters Shellfish-growing waters classified for commercial harvest.

Coliform Bacteria Coliform bacteria are present in sewage and are used to indicate possible the presence of enteric pathogens of sewage origin. Fecal coliform bacteria are a subset of the total coliform bacteria group, and indicate specifically the presence of fecal material.

Conditionally Approved Waters Shellfish-growing waters meet approved classification standards under predictable conditions. These waters are opened to harvest when water quality standards are met and are closed at other times.

Depuration Shellfish from restricted areas are placed in tanks through which bacteria-free water is circulated, usually 48 hours before shellfish are removed for marketing.

Enteric Pathogens Enteric Pathogens are human intestinal bacteria or viruses that cause gastroenteritis or hepatitis.

Estuarine Drainage Area (EDA) An EDA is the land and water component of a watershed that drains directly into estuarine waters.

Harvest-Limited Waters The sum of shellfish-growing waters classified as conditionally approved, restricted, and prohibited.

Landings Landings refer to the quantity of shellfish harvested.

National Shellfish Sanitation Program The NSSP is a cooperative program of the U.S. Food and Drug Administration, shellfish-producing states, and the shellfish industry designed to control harvest and distribution of molluscan shellfish for human consumption.

Offshore Waters The non-estuarine shellfish-growing waters that extend seaward to the three-mile limit are classified as offshore waters.

Prohibited Waters Prohibited shellfish-growing waters may not be harvested for direct marketing. Until 1986, relaying was allowed in prohibited waters.

Relay The transfer of shellfish is permitted from restricted waters to approved waters for natural cleansing, usually for a minimum of 14 days before harvest.

Restricted Waters The shellfish-growing waters may be harvested only if shellfish are relayed or depurated before direct marketing.

Sanitary Survey The NSSP requires that a sanitary survey include the evaluation of all factors determining the classification of waters, including actual and potential pollution sources, hydrographic and meteorologic conditions, and coliform bacteria sampling results.

Shellfish The Register includes only edible species of oysters, clams, scallops, and mussels.

Shellfish Culture Culture includes the propagation, planting, cultivation, and harvest of shellfish.

Courtesy of James L. Amos, National Geographic Society


The 1990 National Shellfish
of Classified